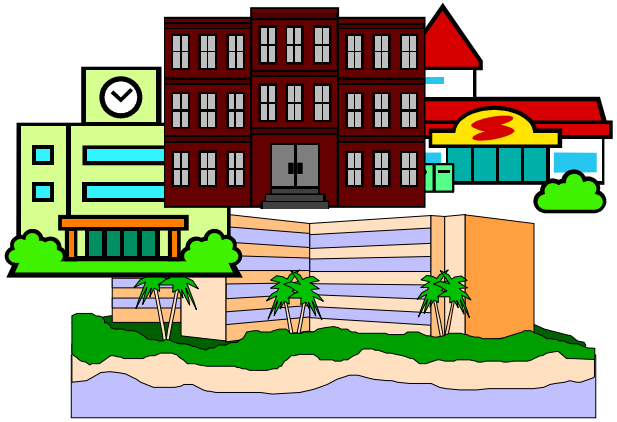
OFFICE OF
BUILDING TECHNOLOGY,
STATE AND COMMUNITY PROGRAMS

Commercial Provisions of the 2001 International Energy Conservation Code

U.S. Department of Energy
Office of Codes and Standards



Produced by the Pacific Northwest National Laboratory

Structure of the IECC

- Chapter 1 Administrative & Enforcement
- Chapter 2 Definitions
- Chapter 3 Design Conditions
- Chapter 4 Residential - Systems Analysis
- Chapter 5 Residential - Component Performance
- Chapter 6 Simplified Prescriptive
- Chapter 7 *ASHRAE 90.1* Reference
- Chapter 8 Design by Acceptable Practice for Commercial Buildings
- Chapter 9 Referenced Standards

Chapter 7 Compared to Chapter 8

- Envelope compliance
- Mechanical compliance
- Service water heating compliance
- Lighting compliance

Building Envelope Chapter 8 Scope

Chapter 8

Section 802

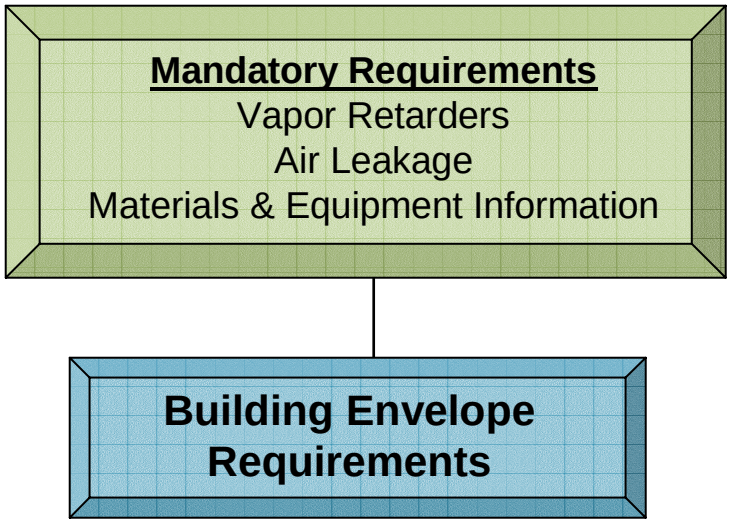
- ≤50% glazing area

Chapter 7

Section 5

IECC Scope

- Envelope requirements

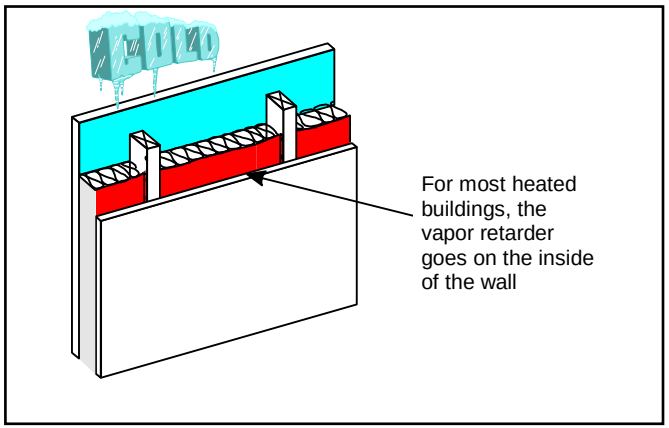


Mandatory Requirements

Vapor Retarder

(Section 802.1.2)

- Install in nonvented framed ceilings, walls, floors
- Must have a Perm Rating of <1.0
- Install on the “warm-in-winter” side of insulation

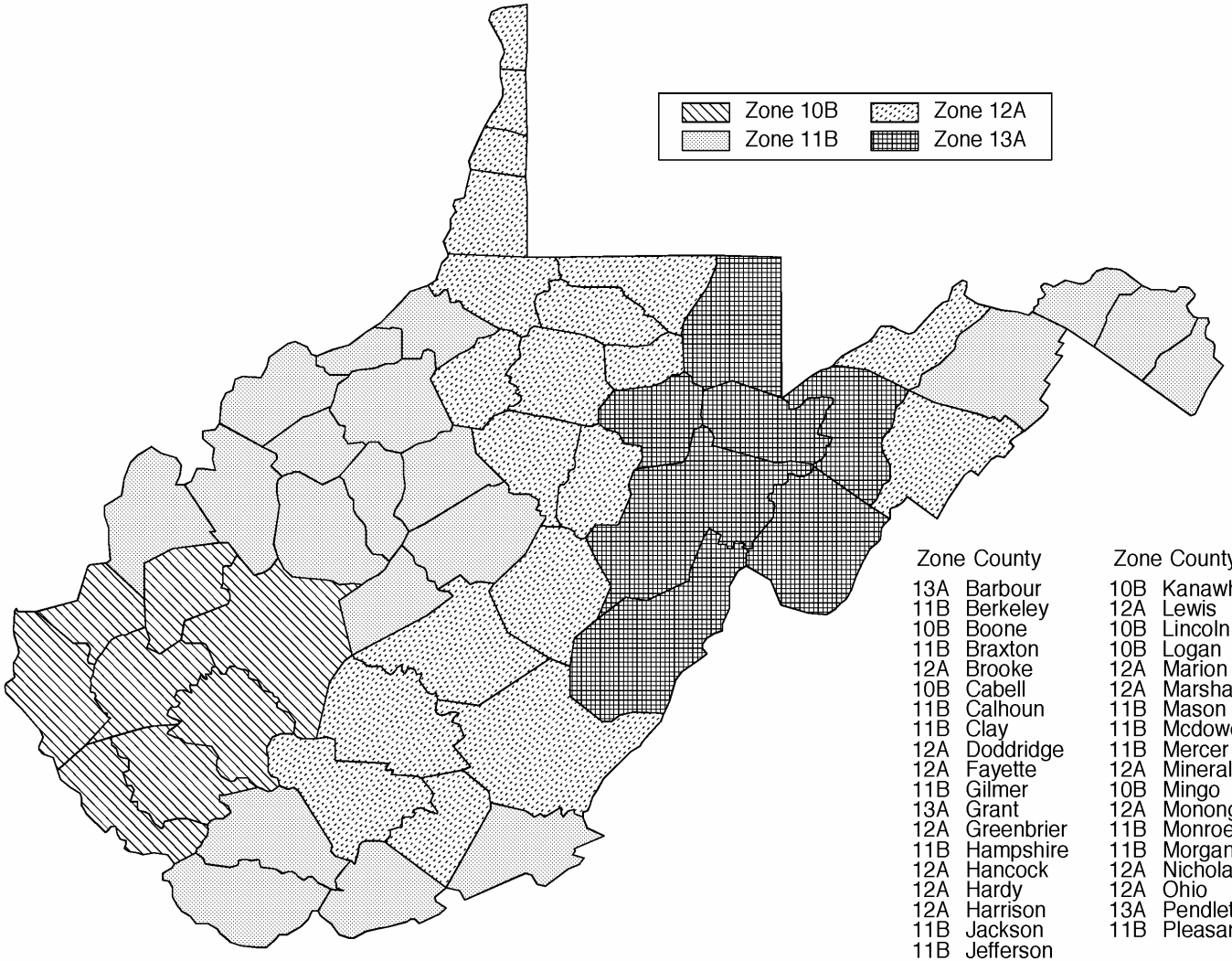


Vapor Retarder

- Exceptions
  - Climate Zones 1 through 7
    - IECC Chapter 3
  - In construction where moisture or its freezing won’t damage materials
  - If other approved means to avoid condensation are provided

IECC Chapter 8

WEST VIRGINIA



Zone	County	Zone	County	Zone	County
13A	Barbour	10B	Kanawha	13A	Pocahontas
11B	Berkeley	12A	Lewis	13A	Preston
10B	Boone	10B	Lincoln	10B	Putnam
11B	Braxton	10B	Logan	12A	Raleigh
12A	Brooke	12A	Marion	13A	Randolph
10B	Cabell	12A	Marshall	11B	Ritchie
11B	Calhoun	11B	Mason	11B	Roane
11B	Clay	11B	Mcdowell	12A	Summers
12A	Doddridge	11B	Mercer	12A	Taylor
12A	Fayette	12A	Mineral	13A	Tucker
11B	Gilmer	10B	Mingo	11B	Tyler
13A	Grant	12A	Monongalia	12A	Upshur
12A	Greenbrier	11B	Monroe	10B	Wayne
11B	Hampshire	11B	Morgan	12A	Webster
12A	Hancock	12A	Nicholas	12A	Wetzel
12A	Hardy	12A	Ohio	11B	Wirt
12A	Harrison	13A	Pendleton	11B	Wood
11B	Jackson	11B	Pleasants	11B	Wyoming
11B	Jefferson				

Mandatory Requirements

Air Leakage

(Section 802.3)

- Windows and doors
- Dampers
- Loading docks
- Vestibules
- Recessed lighting fixtures

Mandatory Requirements

Window, Door and Curtain Wall Assemblies *(Section 802.3.1)*

Air Leakage
- **Windows and doors**
- Dampers
- Loading docks
- Vestibules
- Recessed lighting fixtures

- Manufactured window and door air leakage rates
  - Labeled windows and doors enforced at point of manufacturer
  - Meet AAMA/WDMA 101 windows, doors, and curtain wall assemblies
  - Doors meet ASTM E283
  - Non-labeled windows and doors ~ use manufacturers test results

Mandatory Requirements

Sealing

(Section 802.3.2)

- Building envelope
  - Sealed with caulking materials or
  - Closed with gasketing systems
  - Joints and seams sealed or taped or covered with a moisture vapor-permeable wrapping material

Mandatory Requirements

Dampers

(Section 802.3.3)

Air Leakage
- Windows and doors
- **Dampers**
- Loading docks
- Vestibules
- Recessed lighting fixtures

- Stair, elevator shaft vents and others to have motorized dampers
  - Closed unless required by fire and smoke detection systems
  - Exception
    - Gravity dampers permitted in buildings < 3 stories above grade

Mandatory Requirements

Loading Dock Weatherseals
(Section 802.3.4)

Air Leakage
- Windows and doors
- Dampers
- **Loading docks**
- Vestibules
- Recessed lighting fixtures

- Weatherseals on cargo doors and loading dock doors

Mandatory Requirements

Vestibules

(Section 802.3.5)

Air Leakage
- Windows and doors
- Dampers
- Loading docks
- **Vestibules**
- Recessed lighting fixtures

- Doors separating conditioned space from exterior to have an enclosed vestibule
  - All doors in and out of vestibule to have self-closing devices
- Designed so interior and exterior doors do not have to be open at the same time

Vestibules *(cont'd)*

- Exceptions
  - Climate zones 1a-4b
  - Doors not used as entrance doors
  - Doors directly from guest room or dwelling unit
  - Doors from a space < 3000 ft^2 in area
  - Revolving doors
  - Doors used primarily for vehicular movement or material handling and adjacent to personnel doors

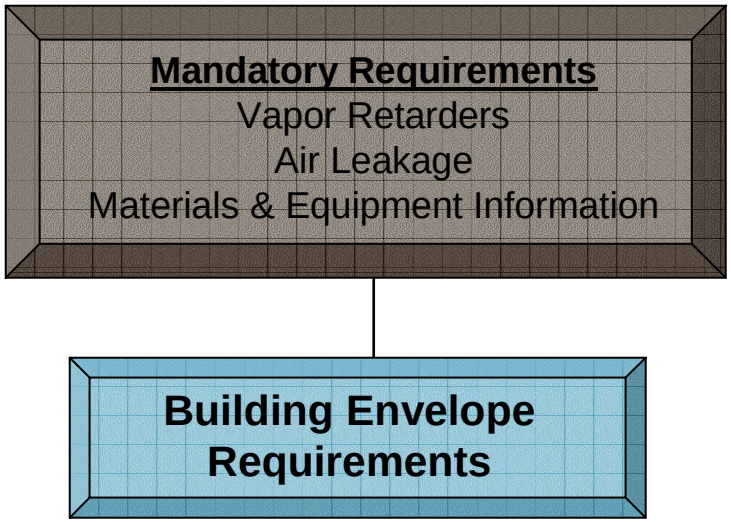
Mandatory Requirements

Recessed Lighting Fixtures
(Section 802.3.6)

Air Leakage
- Windows and doors
- Dampers
- Loading docks
- Vestibules
- **Recessed lighting fixtures**

- Type IC rated, with no penetrations between the inside of the recessed fixture and ceiling cavity (sealed and caulked)
- Type IC or non-IC rated, installed inside a sealed box of ½" gypsum wallboard or other assembly manufactured for this purpose
- Type IC rated, in accordance with ASTM E 283 to be an "Air-Tight" enclosure

Building Envelope Compliance



Envelope Requirements

- Terms
- Requirements
  - Walls
  - Windows
  - Roofs
  - Skylights
  - Floors
  - Slab
  - Below-Grade Walls

Terms Used in Each Code

Component	IECC	90.1
Roofs	R-Value	U-Factor
Above Grade Walls	R-Value	U-Factor
Raised Floors	R-Value	U-Factor
Windows	U-Factor	U-Factor
Skylights	U-Factor	U-Factor
Slab-on-Grade	R-Value	R-Value
Below Grade Walls	R-Value	R-Value

Terms

R-Values

•**Terms**
•Requirements
– Walls
– Windows
– Roofs
– Skylights
– Floors
– Slab
– Below-Grade Walls

- Thermal resistance to heat flow
- The larger the number the better
- The R-value of layers in a construction can be added together

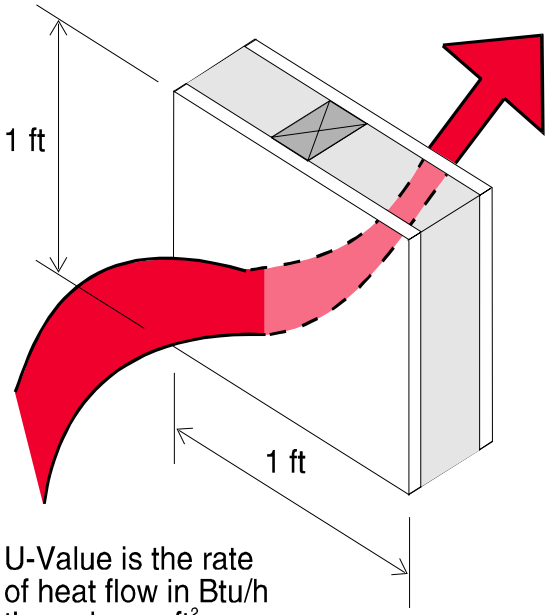
Terms

U-Factors

•Terms
•Requirements
– Walls
– Windows
– Roofs
– Skylights
– Floors
– Slab
– Below-Grade Walls

- The amount of heat in Btu (British thermal units) that flows each hour through one square foot, when there is a 1ºF temperature difference across the surface
- The smaller the number the better

$$U\text{-}Factor = \frac{1}{R\text{-}Value}$$



U-Value is the rate of heat flow in Btu/h through one ft^2 area when one side is 1° F warmer

Building Envelope Requirements

- For buildings ≤ 50% glazing to gross wall area
- Minimal calculations
- Based on:
  - Climate zone
  - Window wall ratio
  - Construction assembly
- All components must meet or exceed building envelope requirements

IECC Chapter 8

IECC Table

GLAZING AREA OVER 10 PERCENT BUT NOT GREATER THAN 25 PERCENT OF ABOVE-GRADE WALL AREA			
ELEMENT	**CONDITION/VALUE**		
Skylights (*U*-value)	0.8		
Slab or below-grade wall (*R*-value)	R-0		
Windows and glass doors	**SHGC**	***U*-value**	
PF < 0.25	0.5	0.6	
0.25 ≤ PF < 0.50	0.6	0.6	
PF ≥ 0.50	0.7	0.6	
Roof assemblies (*R*-value)	**Insulation between framing**	**Continuous insulation**	
All-wood joist/truss	R-25	R-19	
Metal joist/truss	R-25	R-20	
Concrete slab or deck	NA	R-19	
Metal purlin with thermal block	R-30	R-20	
Metal purlin without thermal block	X	R-20	
Floors over outdoor air or unconditioned space (*R*-value)	**Insulation between framing**	**Continuous insulation**	
All-wood joist/truss	R-19	R-12	
Metal joist/truss	R-19	R-13	
Concrete slab or deck	NA	R-13	
Above-Grade Walls (*R*-value)	**No Framing**	**Metal Framing**	**Wood Framing**
Framed			
R-value cavity	NA	R-11	R-11
R-value continuous	NA	R-0	R-0
CMU, ≥ 8 in, with integral insulation			
R-value cavity	NA	R-11	R-11
R-value continuous	R-5	R-0	R-0
Other Masonry Walls			
R-value cavity	NA	R-11	R-11
R-value continuous	R-5	R-0	R-0

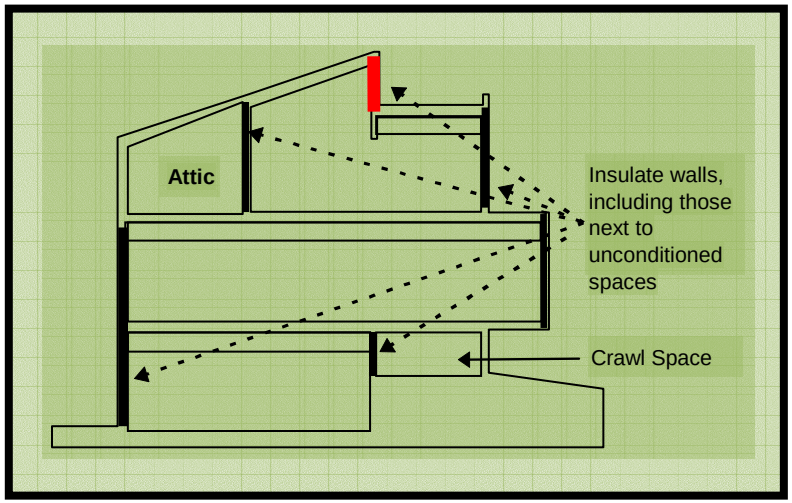
Glazing Area Percentage

- Glazing percentage to Above Grade Wall
  - Gross window area / gross wall area
  - Gross wall area includes
    - Above-grade walls
    - Band joist and subfloor between floors
    - Area of all doors and windows

Envelope Requirements
Walls
(Section 802.2.1)

•Terms
•Requirements
– **Walls**
– Windows
– Roofs
– Skylights
– Floors
– Slab
– Below-Grade Walls

- Meet or exceed R-value requirement
- Insulation between framing members
- Continuous R-value



Envelope Requirements

Nonglazed Doors

(Section 802.2.2)

- Meet applicable requirements for windows and glazed doors
- Be considered a part of gross area of above-grade walls that are part of building envelope

Envelope Requirements

Windows and Glass Doors
(Section 802.2.3)

•Terms
•Requirements
– Walls
– **Windows**
– Roofs
– Skylights
– Floors
– Slab
– Below-Grade Walls

- Requirements based on
  - Solar Heat Gain Coefficient
  - Maximum U-value

Windows - SHGC

- Solar Heat Gain Coefficient
  - Requirements dependent on projection factor
  - National Fenestration Rating Council (NFRC) tested
  - Default SHGC range diagrams
  - SHGC = SC x .87

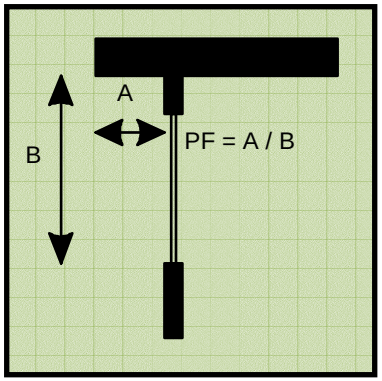


TABLE 102.3(3)
SHGC DEFAULT TABLE FOR FENESTRATION

PRODUCT DESCRIPTION	SINGLE GLAZED				DOUBLE GLAZED			
	Clear	Bronze	Green	Gray	Clear + Clear	Bronze + Clear	Green + Clear	Gray + Clear
Metal frames								
Operable	0.75	0.64	0.62	0.61	0.66	0.55	0.53	0.52
Fixed	0.78	0.67	0.65	0.64	0.68	0.57	0.55	0.54
Nonmetal frames								
Operable	0.63	0.54	0.53	0.52	0.55	0.46	0.45	0.44
Fixed	0.75	0.64	0.62	0.61	0.66	0.54	0.53	0.52

Windows – U-Factors

TABLE 102.3(1)
***U*-VALUE DEFAULT TABLE FOR WINDOWS, GLAZED DOORS AND SKYLIGHTS**

FRAME MATERIAL AND PRODUCT TYPE[a]	SINGLE GLAZED	DOUBLE GLAZED
Metal without thermal break		
Operable (including sliding and swinging glass doors)	1.27	0.87
Fixed	1.13	0.69
Garden window	2.60	1.81
Curtain wall	1.22	0.79
Skylight	1.98	1.31
Site-assembled sloped/overhead glazing	1.36	0.82
Metal with thermal break		
Operable (including sliding and swinging glass doors)	1.08	0.65
Fixed	1.07	0.63
Curtain wall	1.11	0.68
Skylight	1.89	1.11
Site-assembled sloped/overhead glazing	1.25	0.70
Reinforced vinyl/metal clad wood		
Operable (including sliding and swinging glass doors)	0.90	0.57
Fixed	0.98	0.56
Skylight	1.75	1.05
Wood/vinyl/fiberglass		
Operable (including sliding and swinging glass doors)	0.89	0.55
Fixed	0.98	0.56
Garden window	2.31	1.61
Skylight	1.47	0.84

For **SI:** 1 inch = 25.4 mm.

[a] Glass block assemblies with mortar but without reinforcing or framing shall have a *U*-value of 0.60.

- NFRC tested and certified or default window U-value range
- Use assembly U-value
- All windows must meet or exceed

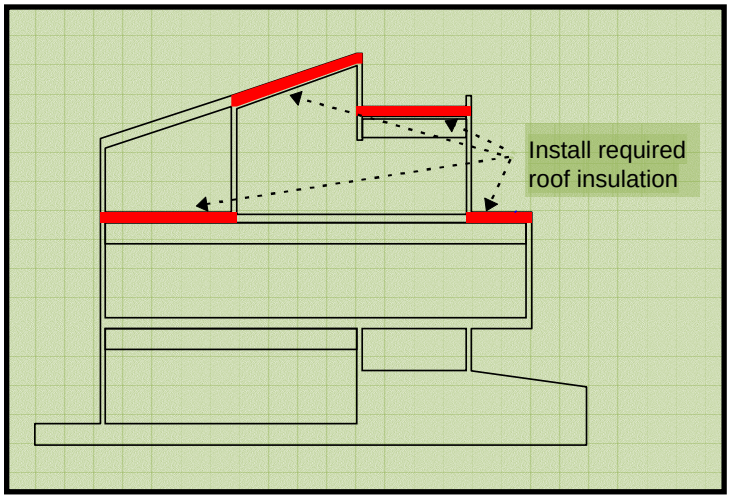
Envelope Requirements

Roofs

(Section 802.2.4)

•Terms
•Requirements
– Walls
– Windows
– **Roofs**
– Skylights
– Floors
– Slab
– Below-Grade Walls

- Requirements based on
  - Assembly type
  - Continuous insulation
  - Insulation between framing
- All R-values must meet or exceed



Envelope Requirements
Skylights
(Section 802.2.5)

- Terms
- Requirements
  - Walls
  - Windows
  - Roofs
  - **Skylights**
  - Floors
  - Slab
  - Below-Grade Walls

- Restricted to ≤ 3% of roof area
  - Requirements based on
    - U-value ~ NFRC tested

    or default U-value table

TABLE 102.3(1)
***U*-VALUE DEFAULT TABLE FOR WINDOWS, GLAZED DOORS AND SKYLIGHTS**

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Garden window	2.31	1.61
Skylight	1.47	0.84

For **SI:** 1 inch = 25.4 mm.

[a] Glass block assemblies with mortar but without reinforcing or framing shall have a *U*-value of 0.60.

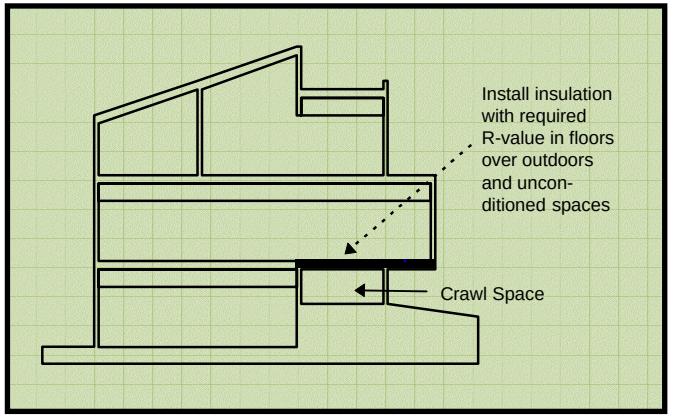
Envelope Requirements

Floors

(Section 802.2.6)

•Terms
•Requirements
– Walls
– Windows
– Roofs
– Skylights
– **Floors**
– Slab
– Below-Grade Walls

- Requirements based on
  - Assembly type
  - Continuous insulation
  - Insulation between framing
- Raised floor insulation
  - Meet or exceed



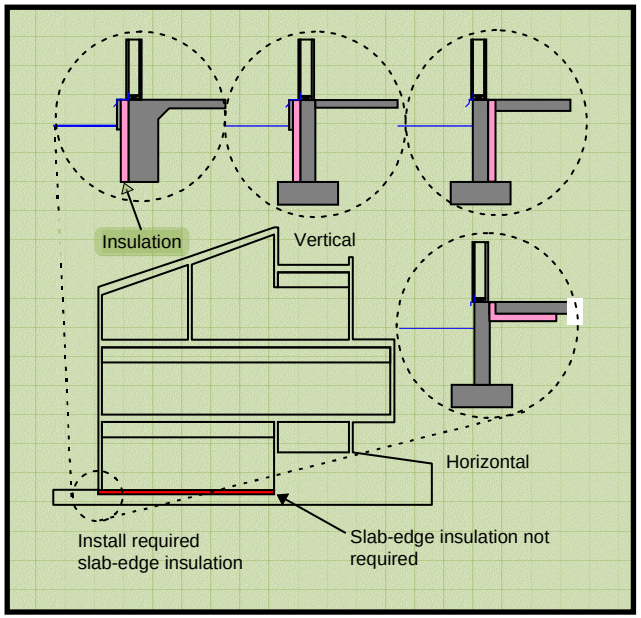
Envelope Requirements

Slab Edge Insulation

(Section 802.2.7)

- Terms
- Requirements
  - Walls
  - Windows
  - Roofs
  - Skylights
  - Floors
  - **Slab**
  - Below-Grade Walls

- Proposed R-value must meet or exceed
- Downward from top of slab a minimum of 48” or
- Downward to at least the bottom of the slab and then horizontally a minimum of 48”



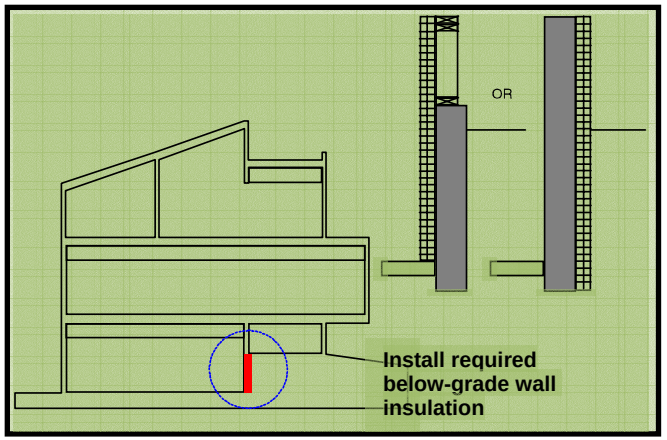
Envelope Requirements

Below-Grade Walls

(Section 802.2.8)

- Terms
- Requirements
  - Walls
  - Windows
  - Roofs
  - Skylights
  - Floors
  - Slab
  - **Below-Grade Walls**

- ≥85% below grade
  - Proposed R-value(s) must meet or exceed required R-value



Building Envelope Chapter 7 Scope

Chapter 8

Section 802

Chapter 7

Section 5

- > 50% glazing area

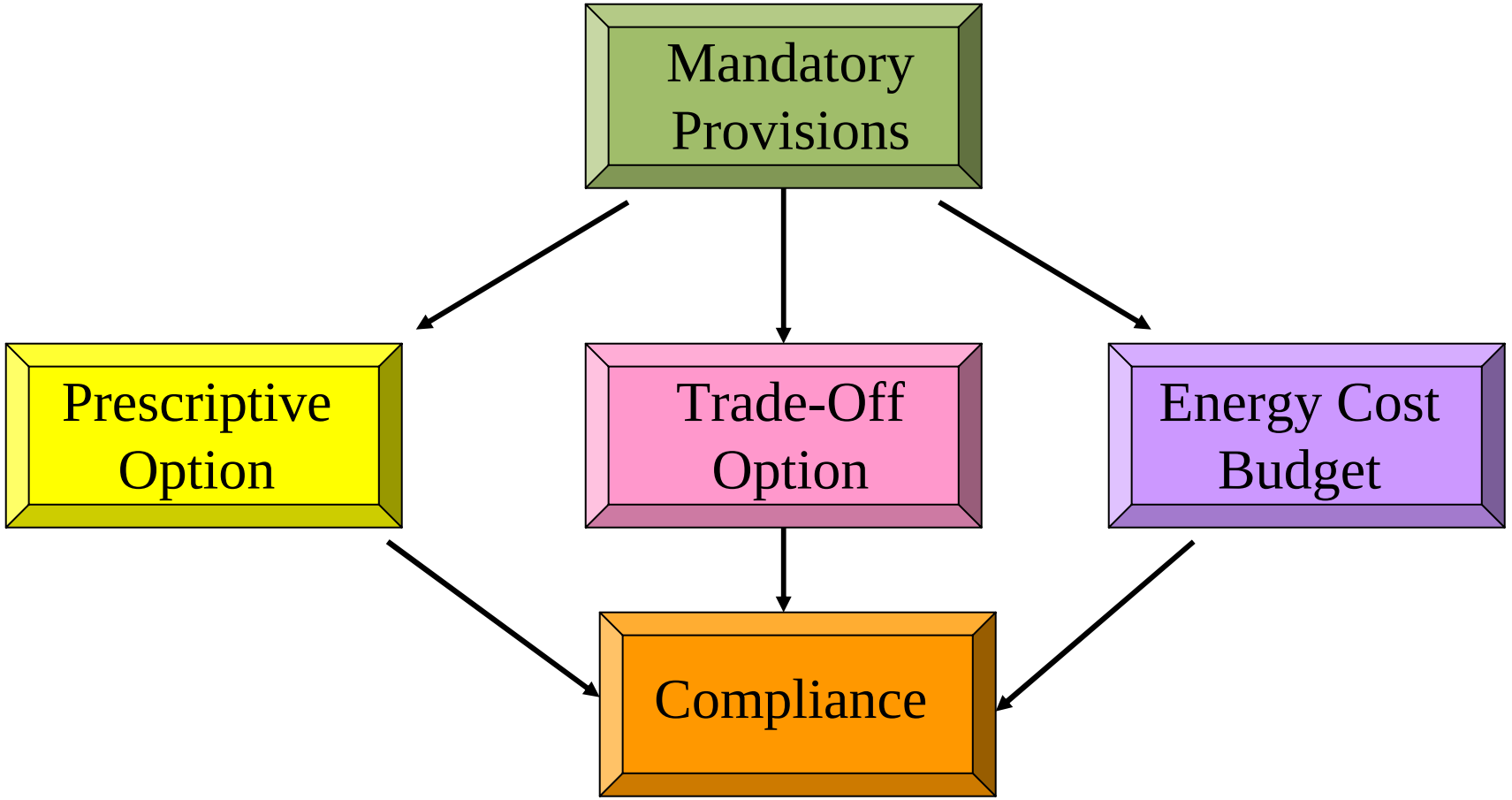
Section 5 – Building Envelope

- General *(Section 5.1)*
  - Scope
  - Compliance
  - Climate
  - Space-Conditioning Categories and Basis
- Mandatory Provisions *(Section 5.2)*
  - Insulation
  - Fenestration and Doors
  - Air Leakage
- Prescriptive Building Envelope Option *(Section 5.3)*
  - Opaque Areas
  - Fenestration
- Building Envelope Trade-Off Options *(Section 5.4)*

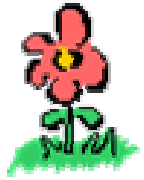
Scope
(Section 5.1.1)

- Envelope components that enclose
  - Conditioned space
  - Semi-heated space
    - Has a heating system with a capacity > 3.4 Btu/h.ft^2 (10 W/m^2) of floor area but is not conditioned space
- Requirements apply to three types of spaces
  - Nonresidential
  - Residential
  - Semi-heated

Envelope Compliance Methods
(Section 5.1.2)



Climate
(Section 5.1.3)

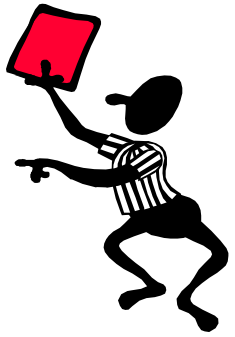


- Bins based on CDD50 and HDD65
  - Locations listed in Appendix D
  - If location not listed, select one with “closest” climatic conditions

Space-Conditioning Categories and Basis *(Section 5.1.4)*

- Each space to be included in a category
  - Nonresidential conditioned space
  - Residential conditioned space
  - Both nonresidential and residential semiheated space
- Spaces in climates > 1800 HDD65 assumed to be conditioned space unless
  - Space will only be semiheated or unconditioned and
  - Approved as such by the building official

Mandatory Provisions



Mandatory Provisions
(Section 5.2)

- Insulation *(Section 5.2.1)*
  - Installation 5.2.1.1 and 5.2.1.2
  - Recessed equipment 5.2.1.3
  - Location of roof insulation and insulation protection 5.2.1.4 and 5.2.1.5

Required in all compliance paths

Mandatory Provisions

Insulation Installation

(Section 5.2.1.1)

- Per manufacturer's instructions
- Achieve rated R-value
- No open-blown or poured loose-fill insulation
  - When ceiling slope is > 3/12
- If eave vents installed
  - Provide baffling of air vents to deflect incoming air above the surface of the insulation
- Exception
  - Metal buildings – if roof and wall insulation is compressed between roof or wall skin and the structure

Mandatory Provisions

Substantial Contact
(Section 5.2.1.2)

- Install insulation in a permanent manner in substantial contact with inside surface
- Flexible batt insulation in floor cavities
  - To be supported in a permanent manner by supports no more than 24 in. o.c.

Mandatory Provisions

Recessed Equipment
(Section 5.2.1.3)

- Do not recess equipment to affect insulation thickness
  - Lighting fixtures
  - HVAC equipment (includes wall heaters, ducts, and plenums)
  - Other
- Except when
  - Total combined area affected (include necessary clearances) is < 1% of opaque area of the assembly, **OR**
  - Entire roof, wall, or floor is covered with insulation to the full depth required, **OR**
  - Effects of reduced insulation are included in area-weighted calculations

Mandatory Provisions

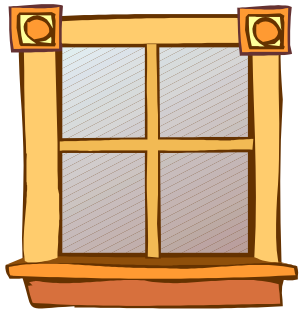
Roof Insulation
(Section 5.2.1.4)

- Roof Insulation
  - Not installed on a suspended ceiling with removable ceiling panels

Mandatory Provisions

Insulation Protection
(Section 5.2.1.5)

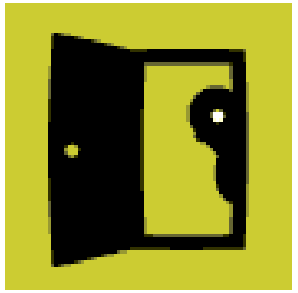
- Insulation Protection
  - Cover exterior insulation with protective material
    - Sunlight
    - Moisture
    - Landscaping operations
    - Equipment maintenance
    - Wind
  - Access to attics and mechanical rooms without damaging or compressing insulation
  - Insulation materials in ground contact to have a water absorption rate $\leq$ 0.3% (ASTM C272)



Mandatory Provisions

Fenestration and Doors

(Section 5.2.2)



- U-factors
  - NFRC 100 or
  - Assemblies listed in Appendix A
- SHGC
  - NFRC 200 or
  - Assemblies listed in Appendix A
- Visible Light Transmittance
  - NFRC 200 when building envelope trade-off option is used

U-Factor

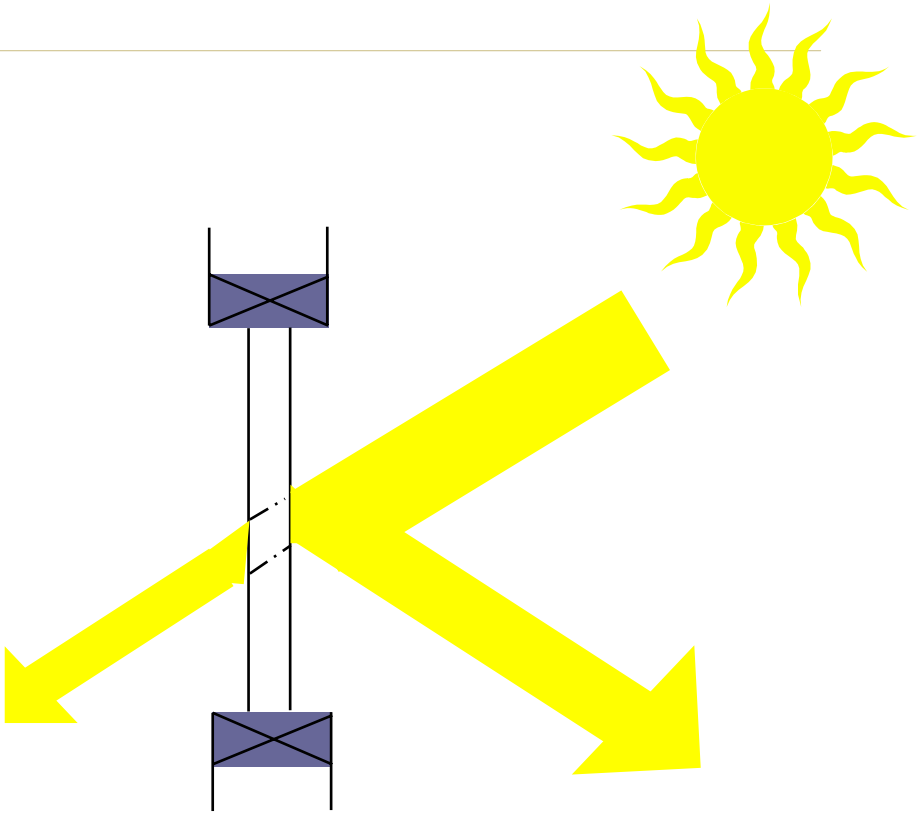
- Skylights – determine for a slope of 20° above the horizontal
- Labeled and certified by manufacturer
- Exceptions
  - Glazed wall systems in vertical fenestration and skylights – may use U-factors in A.8.1
  - A.8.2 acceptable for other vertical fenestration
  - A.7 acceptable for opaque doors
  - NAGDM 105 acceptable for garage doors

Solar Heat Gain Coefficient

- Exceptions
  - SC x 0.86 is acceptable for overall fenestration area (NFRC 300)
  - SHGC of center of glass is acceptable (NFRC 300) for overall fenestration area
  - SHGC from A.8.1 for glazed wall systems in vertical fenestration and skylights
  - SHGC from A.8.2 for other vertical fenestration

SHGC *(cont'd)*

- The glazing's effectiveness in rejecting solar heat gain
- Part of a system for rating window performance
  - used by the National Fenestration Rating Council (NFRC)
- Gradually replacing shading coefficient (SC) in product literature and design standards
  - convert SC to SHGC by multiplying the SC value by 0.86



Visible Light Transmittance

- A measure of the amount of visible light that passes through fenestration
- Affected by:
  - composition of the glass
  - coatings
  - internal shading devices

Mandatory Provisions

Air Leakage

(Section 5.2.3)

- Seal, caulk, gasket, or weather-strip
  - Openings and joints in building envelope
  - Fenestration and doors per NFRC 400
  - Loading docks in climates > 3600 HDD
  - Vestibules and doors separating conditioned space from exterior

Mandatory Provisions

Building Envelope Sealing *(Section 5.2.3.1)*

- Joints around fenestration and door frames
- Junctions between walls
  - and foundations
  - at building corners
  - and structural floors or roofs
  - and roof or wall panels
- Openings for utility services through roofs, walls, and floors
- Site-built fenestration and doors
- Building assemblies used as ducts or plenums
- Joints, seams, and penetrations of vapor retarders
- All other openings in the building envelope

Mandatory Provisions

Fenestration and Doors

(Section 5.2.3.2)

- NFRC 400
- Labeled and certified by manufacturer
- Glazed swinging entrance doors and revolving doors – not to exceed 1.0 cfm/ft^2
- All other products – not to exceed 0.4 cfm/ft^2
- Exceptions
  - Field-fabricated fenestration and doors
  - Garage doors – NAGDM 105

Mandatory Provisions

Loading Dock Weatherseals
(Section 5.2.3.3)

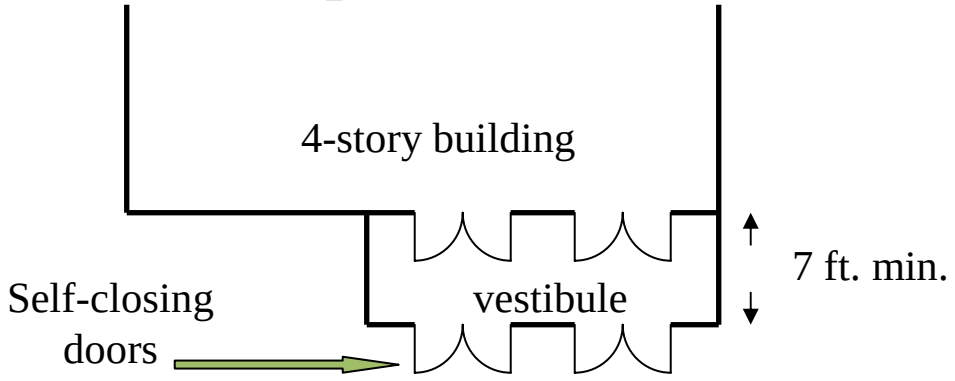
- > 3600 HDD65
  - Cargo doors and loading dock doors equipped with weatherseals
    - To restrict infiltration when vehicles are parked in the doorway

Mandatory Provisions

Vestibules

(Section 5.2.3.4)

- All exterior doors in tall buildings in cold climates must have a vestibule with
  - Self-closing doors
  - Interior and exterior doors must not be open at the same time
  - Distance between interior and exterior doors not < 7 ft when in closed position (remember ADA!)



Vestibule Exceptions

- Non-entrance doors (mechanical/electrical rooms)
- Vehicle and material handling doors and adjacent personnel doors **OR** revolving doors
- All doors in climates < 1800 HDD65 **OR** in buildings
  < 4 stories
- All doors that open into spaces < 3000 ft^2 **OR** into dwelling units

Prescriptive Option

Building Envelope Prescriptive Option
(Section 5.3)

WWR ≤ 50% of gross wall area
Skylight-roof ratio ≤ 5% of roof area
Each envelope component must separately meet requirements

- 26 criteria sets for different climate types
  - Set = single page that summarizes all prescriptive requirements
    - Insulation levels for roofs, walls floors
    - Fenestration criteria

Designers

- Specify
  - R-values for walls, floors, and roofs
  - U-factors for opaque doors
  - U-factor and SHGC for fenestration, OR
- Use
  - Pre-calculated assemblies from Appendix A

Envelope Prescriptive Option

Opaque Areas
(Section 5.3.1)

- Compliance
  - Meet or exceed minimum R-values in table
    - Only R-value of insulation, not to include air films, etc

    OR

    - Meet maximum U-factor, C-factor, or F-factor for the entire assembly

    OR

    - Perform area-weighted average U-factor, C-factor, or F-factor
      - Only if there are multiple assemblies within a single class of construction for a single space-conditioning category

Envelope Prescriptive Option

Roof Insulation

(Section 5.3.1.1)

- Meet or exceed minimum R-value in table
- Skylight curbs insulated to level of roofs with insulation entirely above deck or R-5, whichever is less
- Roofs with insulation entirely above deck
  - R-value is for continuous insulation
  - Interruptions for mechanical equipment ≤ 1% of surface of the total roof area

Roof Insulation *(cont'd)*

- Metal building roofs
  - First value is for
    - insulation draped over purlins and then compressed when metal spanning members attached or
    - insulation hung between purlins provided there's a min. of 1" thermal break between purlins and metal spanning members
  - Second value is for double-layer installations with insulation installed parallel to the purlins
- Attics and other roofs
  - R-value is for insulation installed both inside and outside the roof or entirely inside the roof cavity

Envelope Prescriptive Option

Above-Grade Wall Insulation

(Section 5.3.1.2)

- Meet or exceed R-value in appropriate table
- Mass walls
  - heat capacity determined from Table A-6 or A-7
  - R-value is for continuous insulation or when uninterrupted by framing other than metal clips no closer than 24 in. o.c. horizontally and 16 in. o.c. vertically
- Exception – requirement of U-0.151

Above-Grade Wall Insulation

(cont'd)

- Metal building wall R-value is for insulation compressed between metal wall panels and the steel structure
- Steel-framed wall R-value is for uncompressed insulation installed in the cavity between steel studs
- Wood-framed and other R-value is for uncompressed insulation installed in the cavity between wood studs; also acceptable to be continuous insulation uninterrupted by studs

Envelope Prescriptive Option

Below-Grade Wall Insulation

(Section 5.3.1.3)

- Meet or exceed values in appropriate table in Appendix B
- R-value is for continuous insulation
- If framing is used, compliance is based on maximum assembly C-factor

Envelope Prescriptive Option

Floor Insulation

(Section 5.3.1.4)

- Meet or exceed values in appropriate table in Appendix B
- Mass floors
  - R-value is for continuous insulation
  - If framing is used, compliance is based on maximum assembly U-factor
- Steel joist floors
  - R-value is for uncompressed insulation or spray-on insulation, but is also acceptable for continuous insulation
- Wood-framed and others
  - R-value is for uncompressed insulation, but is also acceptable for continuous insulation

Envelope Prescriptive Option

Slab-on-Grade Floor Insulation *(Section 5.3.1.5)*

- Meet or exceed values in appropriate table in Appendix B (includes R-value and depth or width of insulation)
- Be installed around the perimeter to the distance specified
  - Inside foundation wall – extend downward from top of slab a minimum distance specified or to the top of the footing, whichever is less
  - Outside foundation wall – extend from top of the slab or downward to at least the bottom of the slab and then horizontally to a minimum distance specified

Envelope Prescriptive Option

Opaque Doors

(Section 5.3.1.6)

- Meet or exceed maximum U-factors in appropriate table in Appendix B

Envelope Prescriptive Option

Fenestration

(Section 5.3.2)

- Criteria apply to fenestration, including windows, glass doors, glass block, plastic panels, and skylights
- Compliance
  - Meet or exceed maximum U-factors in table
  - Meet or exceed minimum SHGC in table
  - Use NFRC ratings or default values in Appendix A

Envelope Prescriptive Option

Fenestration Area

(Section 5.3.2.1)

- Total vertical fenestration area to be < 50% of gross wall area
  - Including both fixed and operable vertical fenestration
- Total skylight area to be < 5% of gross roof area
  - Including glass skylights, plastic skylights with a curb, and all skylights without a curb

Envelope Prescriptive Option

Fenestration U-Factor

(Section 5.3.2.2)

- NFRC or meet or exceed maximum U-factors in A-17
- Exception
  - Vertical fenestration complying with Exception (c) to 5.3.2.3 to have a U-factor ≤ U-factor specified for 40% of the gross wall area

Envelope Prescriptive Option

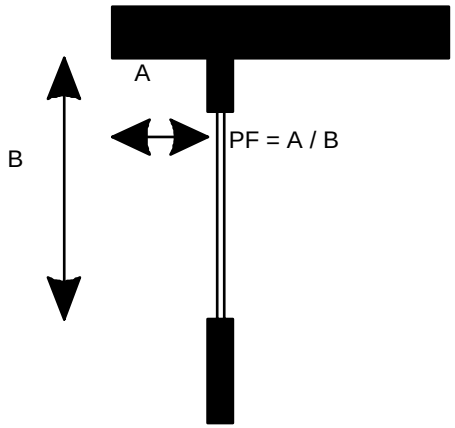
Fenestration SHGC

(Section 5.3.2.3)

- Vertical fenestration
  - SHGC values < Table 5.3 (Appendix A-18) for appropriate total vertical fenestration area
- Skylights
  - SHGC values < Table 5.3 (Appendix A-18) for appropriate total skylight area
- No SHGC requirements for semiheated spaces or for buildings in climates > 10800 HDD65
- Exceptions

Overhangs

- Standard credits permanent overhangs by adjustment to SHGC
- Size of overhang is determined by projection factor



Envelope Prescriptive Option

Visible Light Transmittance

(Section 5.3.2.4)

- No criteria in the Prescriptive Building Envelope Option, but there are minimum criteria in the Building Envelope Trade-Off Option

Trade-Off Option

Building Envelope Trade-Off Option *(Section 5.4)*

- Building complies if
  - It satisfies the provisions of 5.1 and 5.2
  - Envelope performance factor (EPF) of proposed building is ≤ EPF of budget building
  - EPF considers only the building envelope components and is calculated using procedures in Normative Appendix C
  - Schedules of operation, lighting power, equipment power, occupant density, and mechanical systems to be the same for both the proposed building and the budget building

Mechanical Systems
Chapter 8 Scope

Chapter 8

Section 803

Chapter 7

Section 6

Scope

- IECC Chapter 8 encourages efficient mechanical design by:
  - Requiring minimum equipment efficiency
  - Minimizing distribution losses in ductwork
  - Optimizing system controls
  - Requiring acceptable levels of outdoor ventilation

Mechanical System Use Table

Section 803.2	Section 803.3 or Chapter 7
Unitary packaged cooling system	Packaged VAV reheat
Split system cooling	Built-up VAV reheat
Packaged terminal A/C	Built-up single-fan dual-duct VAV
Heat pump cooling	Built-up or packaged dual-fan, dual-duct VAV
Unitary packaged heating	Four-pipe fan coil system with central plant
Split system heating	Hydronic heat pump with central plant
Packaged terminal heat pump	Any other multiple-zone system
Fuel-fired furnace	Hydronic space heating system
Electrical resistance heating	

Mechanical Requirements

- Simple systems *(Section 803.2)*
  - Heating and cooling loads
  - HVAC equipment performance requirement
  - Temperature and humidity controls
  - Hydronic system controls
  - Ventilation
  - Cooling with outdoor air
  - Shutoff dampers
  - Duct and plenum insulation and sealing
  - Piping insulation

Calculation of Heating and Cooling Loads
(Section 803.2.1)

- Simple systems
  - **Heating and cooling loads**
  - HVAC equipment performance requirement
  - Temperature and humidity controls
  - Hydronic system controls
  - Ventilation
  - Cooling with outdoor air
  - Shutoff dampers
  - Duct and plenum insulation and sealing
  - Piping insulation

- In accordance with Chapters 27 and 28 of ASHRAE Handbook of Fundamentals

Equipment Efficiency
(Section 803.2.2)

- Simple systems
  - Heating and cooling loads
  - **HVAC equipment performance requirement**
  - Temperature and humidity controls
  - Hydronic system controls
  - Ventilation
  - Cooling with outdoor air
  - Shutoff dampers
  - Duct and plenum insulation and sealing
  - Piping insulation

- Meet efficiency levels in Tables 803.2.2
- Most packaged equipment is covered by NAECA and must meet the requirements before it can be sold

Efficiency Terms

- EER
  - Energy Efficiency Ratio
  - Ratio of the net cooling capacity, in Btu/h to the total rate of electric input in watts
  - Calculated at full load conditions
  - Units Btu/h per watt

Efficiency Terms *(cont'd)*

- Part Load Performance
  - Annual Fuel Utilization Efficiency (AFUE)
  - Heating Seasonal Performance Factor (HSPF)
  - Seasonal Energy Efficiency Ratio (SEER)

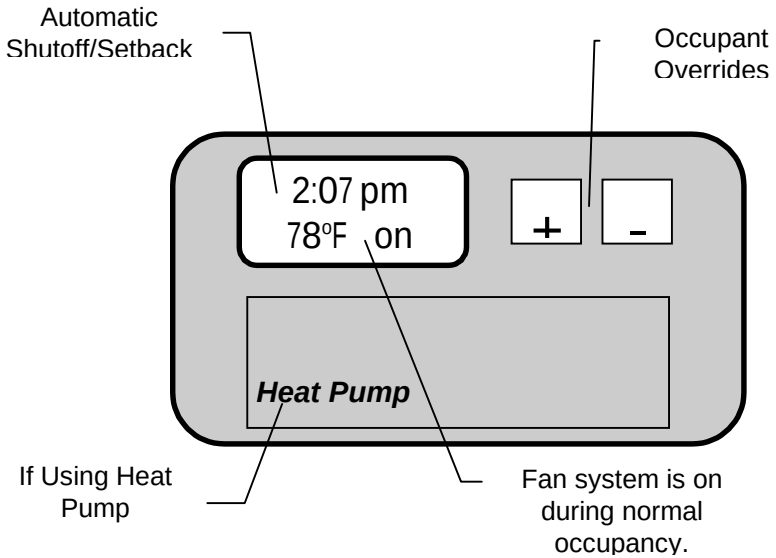
NAECA

- National Appliance Energy Conservation Act
- Specifies equipment performance of heating and cooling equipment, water heaters, and other equipment
- Applicable equipment must meet NAECA before it can be sold in the United States - *No need to enforce at the building department counter*

Heating and Cooling System Controls
(Section 803.2.3)

- Simple systems
  - Heating and cooling loads
  - Equipment and system sizing
  - HVAC equipment performance requirement
  - **Temperature and humidity controls**
  - Hydronic system controls
  - Ventilation
  - Cooling with outdoor air
  - Shutoff dampers
  - Duct and plenum insulation and sealing
  - Piping insulation

- Each system must have a thermostat to control heating and/or cooling to each zone



Humidity Controls
(*Section 803.2.3.2)*

- Simple systems
  - Heating and cooling loads
  - Equipment and system sizing
  - HVAC equipment performance requirement
  - **Temperature and humidity controls**
  - Hydronic system controls
  - Ventilation
  - Cooling with outdoor air
  - Shutoff dampers
  - Duct and plenum insulation and sealing
  - Piping insulation

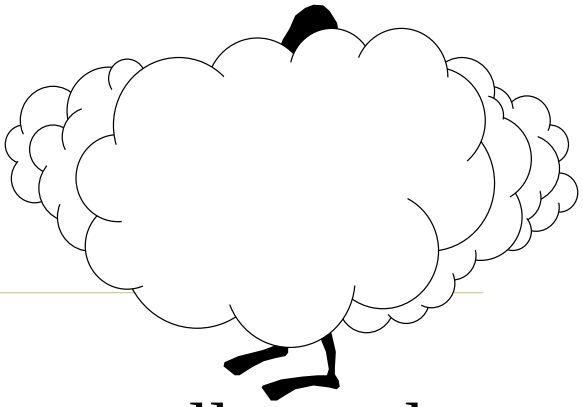
- When installed, prevent use of fossil fuel or electric power to achieve a humidity
  - below 60% when cooling and
  - above 30% when heating

Hydronic System Control
(*Section 803.2.4)*

- Simple systems
  - Heating and cooling loads
  - Equipment and system sizing
  - HVAC equipment performance requirement
  - Temperature and humidity controls
  - **Hydronic system controls**
  - Ventilation
  - Cooling with outdoor air
  - Shutoff dampers
  - Duct and plenum insulation and sealing
  - Piping insulation

- Hydronic systems ≥600,000 Btu/h that supply heated water to comfort systems to have controls meeting 803.3.3.7

Ventilation
(Section 803.2.5)



•Simple systems
- Heating and cooling loads
- Equipment and system sizing
- HVAC equipment performance requirement
- Temperature and humidity controls
- Hydronic system controls
- **Ventilation**
- Cooling with outdoor air
- Shutoff dampers
- Duct and plenum insulation and sealing
- Piping insulation

- Applies to all enclosed spaces normally used by humans
- Spaces must be ventilated
  - Mechanically
  - Naturally
- Use Chapter 4 of the ICC International Mechanical Code (IMC)

Economizers
(Section 803.2.6)

•Simple systems
- Heating and cooling loads
- Equipment and system sizing
- HVAC equipment performance requirement
- Temperature and humidity controls
- Hydronic system controls
- Ventilation
- **Cooling with outdoor air**
- Shutoff dampers
- Duct and plenum insulation and sealing
- Piping insulation

- Air economizers required on systems
  - Cooling capacity > 65,000 Btu/h
- Not required in climate zones 1a, 1b, 2a, 2b, 3b, 5a, 6b
  - Check your location
- Not required if the cooling of proposed equipment meets or exceeds the EER listed in Table 803.2.6
- Not required in climate zones 3c, 5b, 7, 13b, 14 in systems < 135,000 Btu/h cooling capacity

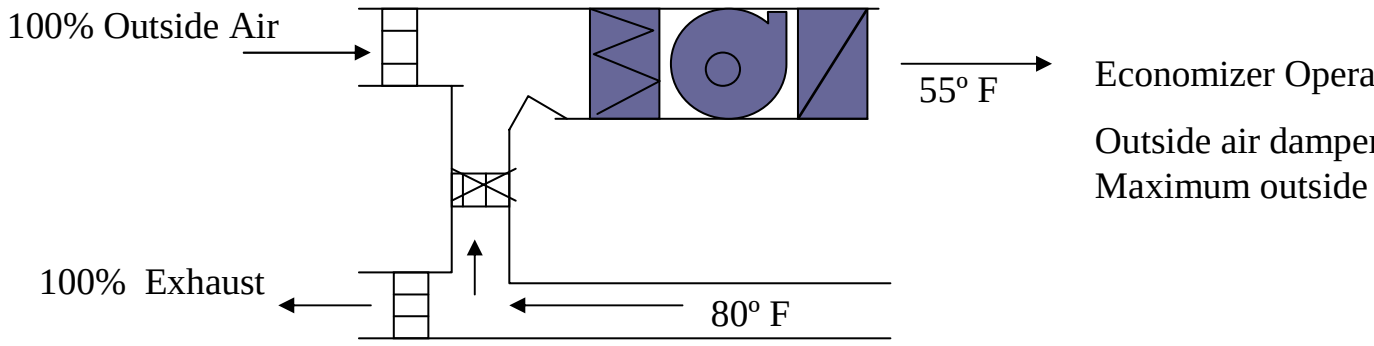
Economizers

- Trade-off high cooling efficiency for economizer
  - Total cooling capacity
  - Climate zones
  - Equipment efficiency (EER)

Total Cooling Capacity of Equipment	**Building Location**		
	Zones 6a, 9a, 10a, 11a, 12a, 12b, 13a, 13b, 14a, 14b, 15, 19	Zones 3a, 4a, 7a, 8, 9b, 10b, 11b	Zones 4b, 5a, 5b, 6b, 7b
90,000 Btu/h to 134,999 Btu/h	N/A	11.4 EER	10.4 EER
135,000 Btu/h to 759,999 Btu/h	N/A	10.9 EER	9.9 EER
760,000 Btu/h or more	N/A	10.5 EER	9.6 EER

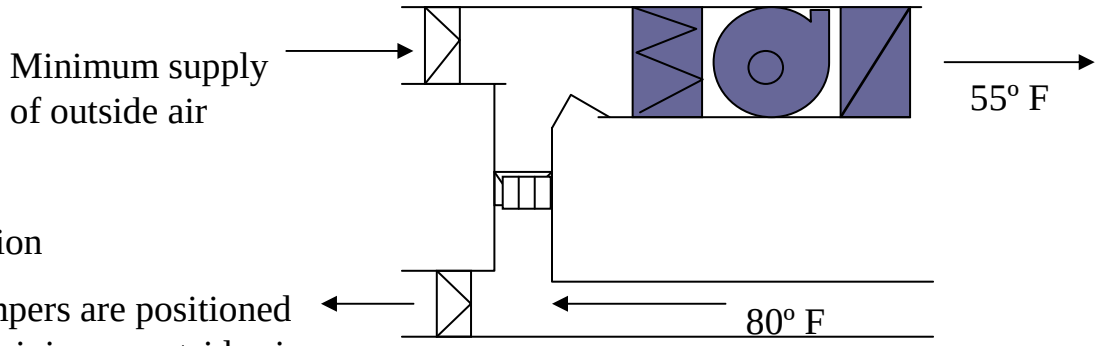
Air-Side Economizers

- Use dampers to increase outside air when outside air cool system requires cooling



Economizer Operation

Outside air dampers are fully open.
Maximum outside air is provided



Normal Operation

Outside air dampers are positioned
to provide the minimum outside air

Shutoff Dampers
(Section 803.2.7)

- Simple systems
  - Heating and cooling loads
  - Equipment and system sizing
  - HVAC equipment performance requirement
  - Temperature and humidity controls
  - Hydronic system controls
  - Ventilation
  - Cooling with outdoor air
  - **Shutoff dampers**
  - Duct and plenum insulation and sealing
  - Piping insulation

- Required for outdoor-air and exhaust systems with design air flow rates > 3000 CFM
- Must automatically close during periods of non-use
- Exceptions
  - Where restricted by health and life safety codes
  - Where serving areas designed for continuous operation
  - Systems with readily accessible manual dampers

Duct and Plenum Insulation
(Section 803.2.8)

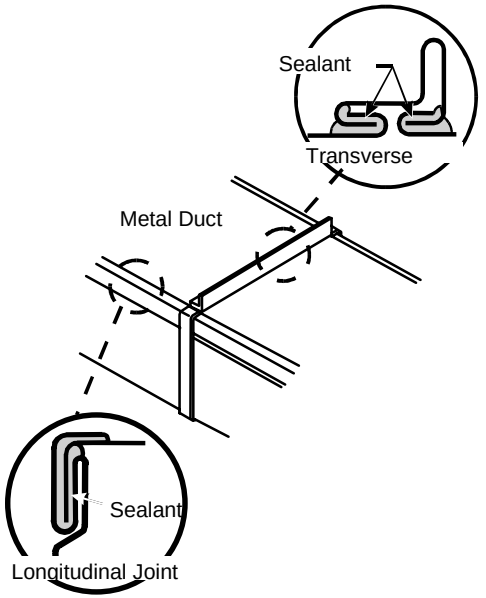
- Simple systems
  - Heating and cooling loads
  - Equipment and system sizing
  - HVAC equipment performance requirement
  - Temperature and humidity controls
  - Hydronic system controls
  - Ventilation
  - Cooling with outdoor air
  - Shutoff dampers
  - **Duct and plenum insulation and sealing**
  - Piping insulation

- Required for supply and return ducts and plenums
  - Located in unconditioned space - R5
  - Located outside the building envelope - R8
- Exceptions
  - Located within equipment
  - Design temperature difference between interior and exterior of duct or plenum ≤ 15°F

Duct Sealing
(Section 803.2.8)

- Simple systems
  - Heating and cooling loads
  - Equipment and system sizing
  - HVAC equipment performance requirement
  - Temperature and humidity controls
  - Hydronic system controls
  - Ventilation
  - Cooling with outdoor air
  - Shutoff dampers
  - **Duct and plenum insulation and sealing**
  - Piping insulation

- Seal and securely fasten all joints, longitudinal and transverse seams and connections with:
  - welds
  - gaskets
  - mastics
  - mastic-plus-embedded fabric systems
  - Tapes
- Duct tape is not permitted as a sealant on any metal ducts



Pipe Insulation
(Section 803.2.9)

- Simple systems
  - Heating and cooling loads
  - Equipment and system sizing
  - HVAC equipment performance requirement
  - Temperature and humidity controls
  - Hydronic system controls
  - Ventilation
  - Cooling with outdoor air
  - Shutoff dampers
  - Duct and plenum insulation and sealing
  - **Piping insulation**

- Thermally insulated according to 803.3.7

Mechanical Requirements

- Complex systems *(Section 803.3)*
  - Heating and cooling loads
  - HVAC equipment performance requirement
  - System controls
    - Thermostatic controls
    - Set point overlap restriction
    - Off-hour controls
    - Shutoff damper controls
    - Economizers
    - Variable air volume fan control
    - Hydronic systems controls
    - Heat rejection equipment fan speed control
  - Multiple zone systems
  - Ventilation
  - Duct and plenum insulation and sealing
  - Piping insulation
  - HVAC system completion

Equipment and System Sizing
(Section 803.3.1.1)

Complex systems

- **–Heating and cooling loads**
- –HVAC equipment performance requirement
- –System controls
  - •Thermostatic controls
  - •Set point overlap restriction
  - •Off-hour controls
  - •Shutoff damper controls
  - •Economizers
  - •Variable air volume fan control
  - •Hydronic systems controls
  - •Heat rejection
- –Multiple zone systems
- –Ventilation
- –Duct and plenum insulation and sealing
- –Piping insulation
- –System completion

- To not exceed 803.2.1
- Exceptions
  - Standby equipment to have controls and devices to operate automatically when primary equipment is not operating
  - Multiple units with combined capacities that exceed design load to have controls to sequence the operation

Equipment Efficiency
(Section 803.3.2)

- Complex systems
  - Heating and cooling loads
  - **HVAC equipment performance requirement**
  - System controls
    - Thermostatic controls
    - Set point overlap restriction
    - Off-hour controls
    - Shutoff damper controls
    - Economizers
    - Variable air volume fan control
    - Hydronic systems controls
    - Heat rejection
  - Multiple zone systems
  - Ventilation
  - Duct and plenum insulation and sealing
  - Piping insulation
  - System completion

- If components from different manufacturers are used
  - Supply calculations and supporting data to demonstrate combined efficiency meets requirements
- If unitary or prepackaged equipment is used in complex systems not covered by 803.3.2, meet 803.2.2

Thermostatic Controls
(Section 803.3.3.1)

- Complex systems
  - Heating and cooling loads
  - HVAC equipment performance requirement
  - System controls
    - **Thermostatic controls**
    - Set point overlap restriction
    - Off-hour controls
    - Shutoff damper controls
    - Economizers
    - Variable air volume fan control
    - Hydronic systems controls
    - Heat rejection
  - Multiple zone systems
  - Ventilation
  - Duct and plenum insulation and sealing
  - Piping insulation
  - System completion

- Individual controls capable of responding to temperature within each zone
- If humidification or dehumidification or both
  - At least one control for each control system

Thermostatic Controls

- Complex systems
  - Heating and cooling loads
  - HVAC equipment performance requirement
  - System controls
    - **Thermostatic controls**
    - Set point overlap restriction
    - Off-hour controls
    - Shutoff damper controls
    - Economizers
    - Variable air volume fan control
    - Hydronic systems controls
    - Heat rejection
  - Multiple zone systems
  - Ventilation
  - Duct and plenum insulation and sealing
  - Piping insulation
  - System completion

- Exceptions
  - Independent perimeter systems

- Heat pump supplementary electric resistance heat
  - Controls to prevent supplementary heat operation when heat pump can meet the heating load (except defrost cycle)

Set Point Overlap Restriction
(Section 803.3.3.2)

- Complex systems
  - Heating and cooling loads
  - HVAC equipment performance requirement
  - System controls
    - Thermostatic controls
    - **Set point overlap restriction**
    - Off-hour controls
    - Shutoff damper controls
    - Economizers
    - Variable air volume fan control
    - Hydronic systems controls
    - Heat rejection
  - Multiple zone systems
  - Ventilation
  - Duct and plenum insulation and sealing
  - Piping insulation
  - System completion

- Controls to have a temperature range or deadband of at least 5°F
- Exception
  - Thermostats requiring manual changeover between heating and cooling modes

Off-hour Controls
(Section 803.3.3.3)

- Complex systems
  - Heating and cooling loads
  - HVAC equipment performance requirement
  - System controls
    - Thermostatic controls
    - Set point overlap restriction
    - **Off-hour controls**
    - Shutoff damper controls
    - Economizers
    - Variable air volume fan control
    - Hydronic systems controls
    - Heat rejection
  - Multiple zone systems
  - Ventilation
  - Duct and plenum insulation and sealing
  - Piping insulation
  - System completion

- Each zone to have setback controls with
  - Automatic time clock or
  - Programmable control system
- Exceptions
  - Continuously-operated zones
  - Zones with full HVAC load demand not exceeding 6800 Btu/hr with a readily accessible manual shutoff switch

Shutoff Damper Controls
(Section 803.3.3.4)

- Complex systems
  - Heating and cooling loads
  - HVAC equipment performance requirement
  - System controls
    - Thermostatic controls
    - Set point overlap restriction
    - Off-hour controls
    - **Shutoff damper controls**
    - Economizers
    - Variable air volume fan control
    - Hydronic systems controls
    - Heat rejection
  - Multiple zone systems
  - Ventilation
  - Duct and plenum insulation and sealing
  - Piping insulation
  - System completion

- Same requirements as in 803.2

Economizers
(Section 803.3.3.5)

- Complex systems
  - Heating and cooling loads
  - HVAC equipment performance requirement
  - System controls
    - Thermostatic controls
    - Set point overlap restriction
    - Off-hour controls
    - Shutoff damper controls
    - **Economizers**
    - Variable air volume fan control
    - Hydronic systems
    - Heat rejection
  - Multiple zone systems
  - Ventilation
  - Duct and plenum insulation and sealing
  - Piping insulation
  - System completion

- Required on each system > 65,000 Btu/h
- Exception
  - Water economizers that can
    - cool supply air by either direct or indirect evaporation or both and
    - provide up to 100% of expected system cooling load at outside air temperatures of 50°F dry bulb/45°F wet bulb and below
  - Systems < 135,000 Btu/h cooling capacity in Climate Zones 3c, 5b, 7, 13b, and 14

VAV Fan Control
(Section 803.3.3.6)

- Complex systems
  - Heating and cooling loads
  - HVAC equipment performance requirement
  - System controls
    - Thermostatic controls
    - Set point overlap restriction
    - Off-hour controls
    - Shutoff damper controls
    - Economizers
    - **Variable air volume fan control**
    - Hydronic systems controls
    - Heat rejection
  - Multiple zone systems
  - Ventilation
  - Duct and plenum insulation and sealing
  - Piping insulation
  - System completion

- Individual fans with motors $\geq$25hp
  - Driven by a mechanical or electrical variable speed drive
  - Be a vane-axial fan with variable pitch blades OR
  - Have controls or devices to result in fan motor demand $\leq$50% of their design wattage at 50% of design airflow when static pressure set point = 1/3 of the total design static pressure

Hydronic Systems Controls
(Section 803.3.3.7)

- Complex systems
  - Heating and cooling loads
  - HVAC equipment performance requirement
  - System controls
    - Thermostatic controls
    - Set point overlap restriction
    - Off-hour controls
    - Shutoff damper controls
    - Economizers
    - Variable air volume fan control
    - **Hydronic systems controls**
    - Heat rejection
  - Multiple zone systems
  - Ventilation
  - Duct and plenum insulation and sealing
  - Piping insulation
  - System completion

- Individual units to have separate hot water and chilled water supply and return piping; not supply hot and chilled water concurrently
- Exception
  - Zones where special humidity levels are required to satisfy process needs

Heat Rejection Equipment Fan Speed Control
(Section 803.3.3.8)

- Complex systems
  - Heating and cooling loads
  - HVAC equipment performance requirement
  - System controls
    - Thermostatic controls
    - Set point overlap restriction
    - Off-hour controls
    - Shutoff damper controls
    - Economizers
    - Variable air volume fan control
    - Hydronic systems controls
    - **Heat rejection**
  - Multiple zone systems
  - Ventilation
  - Duct and plenum insulation and sealing
  - Piping insulation
  - System completion

- Each fan powered by a motor ≥7.5 hp to
  - have capability to operate that fan at 2/3 of full speed or less
  - Have controls to automatically change the fan speed to control the leaving fluid temperature or condensing temperature/pressure of the heat rejection device
- Exception
  - Factory-installed heat rejection devices within HVAC equipment tested and rated in accordance with Tables 803.3.2(1) through 803.3.2(3)

Requirements for Complex Mechanical Systems Serving Multiple Zones *(Section 803.3.4)*

- Complex systems
  - Heating and cooling loads
  - HVAC equipment performance requirement
  - System controls
    - Thermostatic controls
    - Set point overlap restriction
    - Off-hour controls
    - Shutoff damper controls
    - Economizers
    - Variable air volume fan control
    - Hydronic systems controls
    - Heat rejection
  - **Multiple zone systems**
  - Ventilation
  - Duct and plenum insulation and sealing
  - Piping insulation
  - System completion

- Systems shall be VAV systems that are designed and capable of being controlled to reduce primary air supply to each zone to a minimum before reheating, recooling or mixing takes place
- Several exceptions

Ventilation
(Section 803.3.5)

- Complex systems
  - Heating and cooling loads
  - HVAC equipment performance requirement
  - System controls
    - Thermostatic controls
    - Set point overlap restriction
    - Off-hour controls
    - Shutoff damper controls
    - Economizers
    - Variable air volume fan control
    - Hydronic systems controls
    - Heat rejection
  - Multiple zone systems
  - **Ventilation**
  - Duct and plenum insulation and sealing
  - Piping insulation
  - System completion

- Requirements are in 803.2.5

Duct and Plenum Insulation and Sealing
(Section 803.3.6)

- Complex systems
  - Heating and cooling loads
  - HVAC equipment performance requirement
  - System controls
    - Thermostatic controls
    - Set point overlap restriction
    - Off-hour controls
    - Shutoff damper controls
    - Economizers
    - Variable air volume fan control
    - Hydronic systems controls
    - Heat rejection
  - Multiple zone systems
  - Ventilation
  - **Duct and plenum insulation and sealing**
  - Piping insulation
  - System completion

- In accordance with 803.2.8
- Ducts designed to operate at static pressures > 3 in. wg to be leak tested in accordance with SMACNA
- Furnish documentation that representative sections totaling at least 25% of the duct area have been tested and meet the requirements

Piping Insulation
(Section 803.3.7)

- Complex systems
  - Heating and cooling loads
  - HVAC equipment performance requirement
  - System controls
    - Thermostatic controls
    - Set point overlap restriction
    - Off-hour controls
    - Shutoff damper controls
    - Economizers
    - Variable air volume fan control
    - Hydronic systems controls
    - Heat rejection
  - Multiple zone systems
  - Ventilation
  - Duct and plenum insulation and sealing
  - **Piping insulation**
  - System completion

- In accordance with Table 803.3.7
- Exceptions
  - Factory-installed piping within equipment
  - Piping conveying fluids between 55°F and 105°F
  - Piping conveying fluids not heated or cooled through the use of fossil fuels or electric power
  - Runout piping not exceeding 4 ft in length and 1 in. in diameter between the control valve and HVAC coil

HVAC System Completion
(Section 803.3.8)

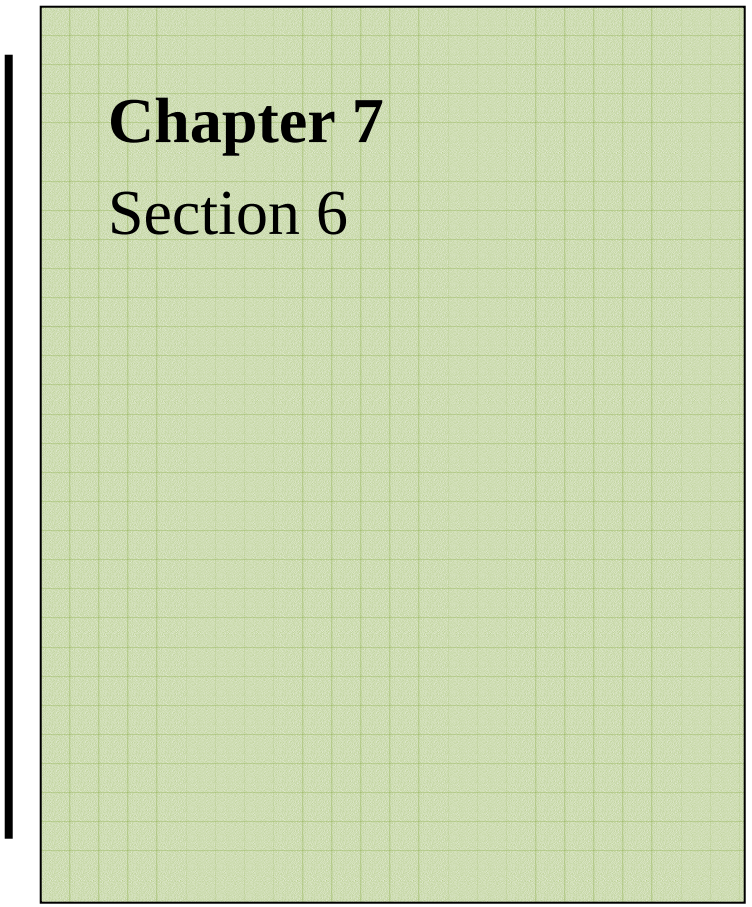
- Complex systems
  - Heating and cooling loads
  - HVAC equipment performance requirement
  - System controls
    - Thermostatic controls
    - Set point overlap restriction
    - Off-hour controls
    - Shutoff damper controls
    - Economizers
    - Variable air volume fan control
    - Hydronic systems controls
    - Heat rejection
  - Multiple zone systems
  - Ventilation
  - Duct and plenum insulation and sealing
  - Piping insulation
  - **System completion**

- Before issuance of certificate of occupancy
  - Air system balancing
  - Hydronic system balancing
  - Manuals

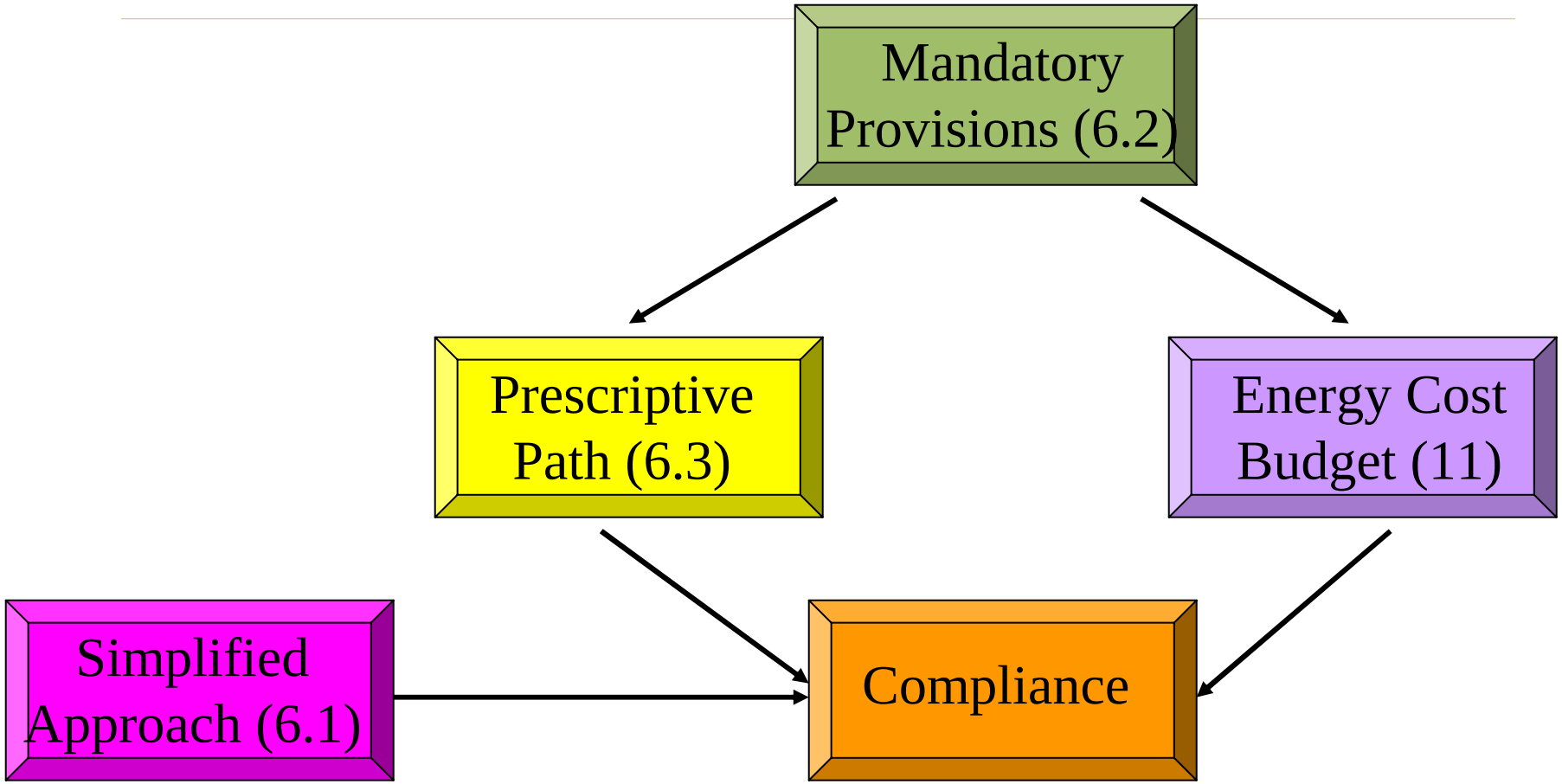
Mechanical Systems
Chapter 7 Scope

Chapter 8

Section 803



Section 6 - HVAC Compliance



Simplified Approach

Simplified Approach Option

(Section 6.1)

- Limited to…
  - Buildings with 1 or 2 stories
  - Buildings < 25,000ft^2
  - Single-zone systems
  - Air-cooled or evaporatively cooled only

Simplified *(cont'd)*

- Manual changeover or dual set-point thermostat
- Heat pump supplementary control
- No reheat or simultaneous heating and cooling for humidity control
- Time clocks (except hotel/motel…)
- Pipe and ductwork insulated
- Ducted system to be air balanced to within 10% of design air flow rates
- Interlocked thermostats to prevent simultaneous heating and cooling
- Exhausts (design capacity > 300 cfm unless continuous operation)
- Optimum start controls (design supply air capacity > 10,000 cfm)

Mandatory Provisions

HVAC Mandatory Provisions
(Section 6.2)

- Mechanical Equipment Efficiency *(Section 6.2.1)*
- Load Calculations *(Section 6.2.2)*
- Controls *(Section 6.2.3)*
- HVAC System Construction and Insulation *(Section 6.2.4)*
- Completion Requirements *(Section 6.2.5)*

Required in both Prescriptive and ECB compliance paths

Equipment Covered

- Package air conditioners
- Heat pumps
- Chillers
- Furnaces
- Boilers
- Heat rejection equipment
- Packaged terminal room air conditioners

Equipment Covered for the First Time in 90.1

- Ground-source heat pumps
- Single- and double-effect absorption chillers
- Heat rejection equipment
- New categories for
  - Hot water and steam boilers
  - Replacement PTACs and PTHPs

HVAC Mandatory Provisions

Mechanical Equipment Efficiency

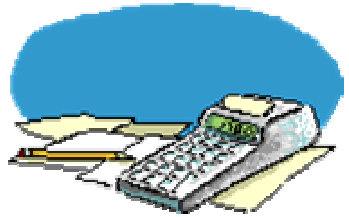
(Section 6.2.1)

- Tables 6.2.1A – 6.2.1G
- Combination systems to meet all requirements for appropriate space heating or cooling category
- Gas-fired and oil-fired forced air furnaces with input ratings ≥ 225,000 Btu/h to have intermittent ignition or interrupted device and have either power venting or a flue damper
- All furnaces with input ratings ≥ 225,000 Btu/h, including electric furnaces, not located in conditioned space, to have jacket losses ≤ 0.75% of the input rating

HVAC Mandatory Provisions

Load Calculations

(Section 6.2.2)



- Determined in accordance with generally accepted engineering standards and handbooks acceptable to the adopting authority

HVAC Mandatory Provisions

Controls
(Section 6.2.3)

- Thermostatic controls *(Section 6.2.3.1)*
  - Required for each zone
  - Dead Band controls
  - Set Point Overlap Restrictions
- Off-Hour controls *(Section 6.2.3.2)*
  - Automatic Shutdown
  - Setback Controls
  - Optimum Start Controls
  - Shutoff Damper Controls
  - Zone Isolation

HVAC Mandatory Provisions

Controls
(Section 6.2.3)

- Gravity Vent Controls *(Section 6.2.3.3)*
  - Stair and Shaft Vent dampers
  - Gravity Hoods, Vents, and Ventilator Dampers
- Heat Pump Auxiliary Heat Control *(Section 6.2.3.4)*
- Enclosed Parking Garage Ventilation controls *(Section 6.2.3.5)*

HVAC Mandatory Provisions

Controls
(Section 6.2.3)

- Humidifier Preheat Controls *(Section 6.2.3.6)*
- Humidification and Dehumidification Controls *(Section 6.2.3.7)*
- Freeze Protection and Ice Melting Systems Controls *(Section 6.2.3.8)*
- Ventilation Controls for High-Occupancy Areas *(Section 6.2.3.9)*
- Exceptions

HVAC Mandatory Provisions/Controls

Dead Band

(Section 6.2.3.1.2)

- Thermostats must have a 5°F dead band
- Exceptions
  - Thermostats that require manual changeover between heating and cooling modes
  - Special occupancy or applications where wide temperature ranges aren't acceptable (e.g., retirement homes) and approved by adopting authority

HVAC Mandatory Provisions/Controls

Set Point Overlap Restriction

(Section 6.2.3.1.3)

- If limit switches, mechanical stops, or software programming for DDC systems are used, means will be provided to prevent the heating set point from exceeding the cooling set point minus any applicable proportional band

HVAC Mandatory Provisions/Controls

Off-Hour Controls

(Section 6.2.3.2)

- Systems with heating/cooling capacity > 65,000 Btu/h and fan > ¾ hp

  Shall have the following off-hour controls

  - automatic shutdown
  - setback controls
  - optimum start controls
  - shutoff damper controls
  - zone isolation

- Exceptions, HVAC systems
  - serving hotel/motel guestrooms
  - intended to operate continuously

HVAC Mandatory Provisions/Controls

Automatic Shutdown

(Section 6.2.3.2.1)

- Controls to operate on different time schedules for seven different day-types per week and retain programming and time setting during loss of power for at least 10 hrs
- Each control to have
  - Occupant sensor, **OR**
  - Manually-operated timer with maximum two hour duration, **OR**
  - Interlock to security system

HVAC Mandatory Provisions/Controls

Setback Controls

(Section 6.2.3.2.2)

- Applies when heating systems are located where heating design temperature is ≤ 40°F and cooling systems located where cooling design temperature < 100°F
- Heating set point adjustable down to ≤ 55°F
- Cooling set point adjustable up to ≥ 90°F or to prevent high space humidity levels
- Exception
  - Radiant floor and ceiling heating systems

HVAC Mandatory Provisions/Controls

Optimum Start Controls

(Section 6.2.3.2.3)

- Individual heating and cooling air distribution systems with
  - Total design supply air capacity > 10,000 cfm
  - Served by one or more supply fans
- Control algorithm to at least be a function of
  - Difference between space temperature and occupied setpoint and amount of time prior to scheduled occupancy

HVAC Mandatory Provisions/Controls

Shutoff Damper Controls

(Section 6.2.3.2.4)

- Motorized dampers for outdoor air supply and exhaust systems
- Ventilation outside air dampers to be capable of automatically shutting off during
  - Preoccupancy building warm up, cool down, and setback

  (Except when ventilation reduces energy costs or when ventilation must be supplied to meet code requirements)
- Supply and exhaust dampers to have maximum leakage rate of 3 cfm/ft^2 at 1.0 in. w.g. when tested in accordance with AMCA Standard 500

HVAC Mandatory Provisions/Controls

Shutoff Damper Controls - Exceptions *(Section 6.2.3.2.4)*

- Gravity dampers okay in buildings
  - < 3 stories in height
  - Of any height in climates < 2700 HDD65
- Systems with design outside air intake or exhaust capacity ≤ 300 cfm
  - if equipped with motor-operated dampers that open and close when unit is energized and de-energized, respectively

HVAC Mandatory Provisions/Controls

Zone Isolation

(Section 6.2.3.2.5)

- Each isolation area
  - Maximum 25,000 ft^2 zone on one floor
  - Ability to shut off airflow to isolation area
  - Automatic shutdown device
  - Central systems capable of stable operation for smallest isolation area

HVAC Mandatory Provisions/Controls

Stair and Shaft Vents

(Section 6.2.3.3.1)

- Motorized dampers
  - Can be automatically closed during normal building operation
  - Interlocked to open as required by fire and smoke detection systems

HVAC Mandatory Provisions/Controls

Gravity Hoods, Vents, and Ventilators *(Section 6.2.3.3.2)*

- Motorized dampers to automatically shut when spaces served are not in use
- Exceptions
  - Gravity dampers okay in buildings
    - < 3 stories in height
    - Of any height in climates < 2700 HDD65

HVAC Mandatory Provisions/Controls

Heat Pump Auxiliary Heat Control *(Section 6.2.3.4)*

- Controls to prevent supplementary heat when heat pump can handle the load
- Exception
  - Heat pumps
    - With minimum efficiency regulated by NAECA
    - With HSPF rating meeting Table 6.2.1B

    (Includes all usage of internal electric resistance heating)

HVAC Mandatory Provisions/Controls

Enclosed Parking Garage Ventilation *(Section 6.2.3.5)*

- Garage ventilation fan systems with total design capacity > 30,000 cfm to have at least one
  - Automatic control capable of staging fans or modulating fan volume as required to maintain CO levels below ASHRAE Standard 62 (only applies to garages used predominantly by gasoline-powered vehicles)
  - Automatic control complying with 6.2.3.2.1 that's capable of shutting off fans or reducing fan volume during periods when garage is not in use

HVAC Mandatory Provisions/Controls

Humidifier Preheat

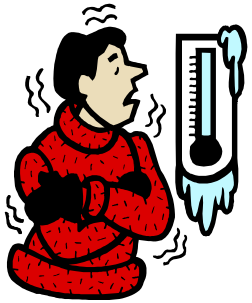
(Section 6.2.3.6)

- Automatic valve to shut off preheat when humidification isn't required

HVAC Mandatory Provisions/Controls

Humidification and Dehumidification *(Section 6.2.3.7)*

- Provide means to prevent simultaneous operation of humidification and dehumidification equipment
  - Limit switches, mechanical stops, or software programming (DDC systems)
- Exceptions
  - Zones served by desiccant systems, used with direct evaporative cooling in series
  - Systems serving zones where specific humidity levels are required and approved by jurisdiction
    - Computer rooms, museums, and hospitals



HVAC Mandatory Provisions/Controls

Freeze Protection and Snow/Ice *(Section 6.2.3.8)*

- Automatic controls for
  - freeze protection systems
    - outside air temperatures > 40°F or when conditions of protected fluid will prevent freezing
  - Snow- and ice-melting systems
    - pavement temperature > 50°F and no precipitation is falling and outdoor temperature > 40°F

HVAC Mandatory Provisions

HVAC System Construction and Insulation *(Section 6.2.4)*

- Insulation installed in accordance with industry accepted standards
- Insulation protection
- Duct and plenum insulation
- Duct Sealing
- Duct Leakage Testing
- Piping Insulation

HVAC Mandatory Provisions

General
(Section 6.2.4.1)

- Insulation installed in accordance with industry accepted standards
- Insulation
  - Protected from damage due to sunlight, moisture, equipment maintenance, and wind
  - Exposed to weather to be suitable for outdoor service
  - Covering chilled water piping, refrigerant suction piping, or cooling ducts located outside the conditioned space to include a vapor retardant located outside the insulation, all penetrations and joints of which to be sealed

HVAC Mandatory Provisions/HVAC Insulation

Duct and Plenum Insulation *(Section 6.2.4.2)*

- All supply and return ducts and plenums to be insulated per Tables 6.2.4.2A and 6.2.4.2B
- Exceptions
  - Factory-installed plenums, casings, or ductwork furnished as part of HVAC equipment
  - Ducts located in heated, semi-heated, or cooled spaces
  - For runouts < 10 ft in length to air terminals or air outlets, the R-value need not exceed R-3.5
  - Backs of air outlets and outlet plenums exposed to unconditioned or indirectly conditioned spaces with face areas > 5 ft^2 need not exceed R-2; those ≤ 5 ft^2 need not be insulated

HVAC Mandatory Provisions/HVAC Insulation

Duct Sealing
(Section 6.2.4.3)

- Table 6.2.4.3A
- Requirements of 6.2.4.4
- Standard industry practice

Duct Leakage Tests
(Section 6.2.4.4)

- Designed > 3 in. w.c.
  - Leak tested
  - Representative sections ≥ 25% of the total installed duct area shall be tested
  - Ratings > 3 in. w.c. to be identified on drawings
  - Maximum permitted duct leakage
    - $L_{max} = C_L P^{0.65}$

Where L_{max} = maximum permitted leakage in cfm/100 ft^2 duct surface area

HVAC Mandatory Provisions/HVAC Insulation

Piping Insulation
(Section 6.2.4.5)

- Table 6.2.4.5
- Exceptions
  - Factory-installed
  - Piping conveying fluids
    - design operating temperature range between 60°F-105°F, inclusive
    - that haven't been heated or cooled through the use of nonrenewable energy or where heat gain or heat loss will not increase energy usage
  - Hot water piping between shut off valve and coil, not > 4 ft in length, when located in conditioned spaces
  - Pipe unions in heating systems (steam, steam condensate, and hot water)

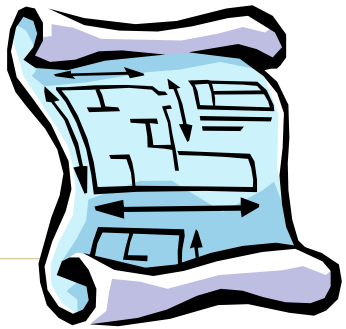
HVAC Mandatory Provisions

Completion Requirements

(Section 6.2.5)

- Record drawings
- Operating and maintenance manuals
- System balancing
- System commissioning

Drawings
(Section 6.2.5.1)



- Record drawings of actual installation to building owner within 90 days of system acceptance and include, as a minimum
  - Location and performance data on each piece of equipment
  - General configuration of duct and pipe distribution system including sizes
  - Terminal air or water design flow rates

HVAC Mandatory Provisions/Completion Req

Manuals

(Section 6.2.5.2)

- Operating and maintenance manuals to building owner within 90 days of system acceptance and include, as a minimum

HVAC Mandatory Provisions/Completion Req

System Balancing
(Section 6.2.5.3.1)

- Measured and adjusted within 10% of design rates
- Exception
  - Variable speed, variable volume flow distribution systems need not be balanced upstream of a pressure independent device
- Written report for conditioned spaces > 5000 ft^2

HVAC Mandatory Provisions/Completion Req

Air System Balancing
(Section 6.2.5.3.2)

- Minimize throttling losses
- For fans with system power > 1 hp
  - Adjust fan speed to meet design flow conditions (except variable flow distribution systems need not be balanced upstream of the controlling device)

HVAC Mandatory Provisions/Completion Req

Hydronic System Balancing

(Section 6.2.5.3.3)

- Proportionately balanced to minimize throttling losses
- Pump impeller trimmed or pump speed adjusted to meet design flow conditions
- Each system to have either the ability to measure differential pressure increase across the pump or have test ports at each side of the pump
- Exceptions
  - Pumps with pump motors ≤ 10 hp
  - When throttling results in < 5% of the nameplate hp draw, or 3 hp, whichever is greater, above that required if the impeller was trimmed

HVAC Mandatory Provisions/Completion Req

System Commissioning
(Section 6.2.5.4)

- Control elements are calibrated, adjusted, and in proper working condition
- > 50,000 ft^2 conditioned area
  - Except warehouses and semiheated spaces
  - Requires commissioning plan

Prescriptive Path

HVAC Prescriptive Path
(Section 6.3)

- Economizers *(Section 6.3.1)*
- Simultaneous Heating and Cooling Limitation *(Section 6.3.2)*
- Air System Design and Control *(Section 6.3.3)*
- Hydronic System Design and Control *(Section 6.3.4)*
- Heat Rejection Equipment *(Section 6.3.5)*
- Energy Recovery *(Section 6.3.6)*
- Exhaust Hoods *(Section 6.3.7)*
- Radiant Heating Systems *(Section 6.3.8)*
- Hot Gas Bypass Limitation *(Section 6.3.9)*

HVAC Prescriptive Path

Economizers

(Section 6.3.1)

- Climate and size dependent (Table 6.3.1)
- There are LOTS of exceptions
- Can use air economizers
  - 100% of design supply air
  - Sequenced with mechanical cooling equipment
  - High limit shutoff
  - Dampers
- Can use water economizers
  - 100% of expected system cooling load
  - Maximum pressure drop

HVAC Prescriptive Path/Air Economizers

Design Capacity
(Section 6.3.1.1.1)

- System capable of modulating outside air and return air dampers to provide up to 100% of the design supply air quantity as outside air for cooling

HVAC Prescriptive Path/Air Economizers

Control Signal
(Section 6.3.1.1.2)

- Dampers capable of being sequenced with the mechanical cooling equipment and shall not be controlled by only mixed air temperature
- Exception
  - Systems controlled from space temperature (such as single-zone systems)

HVAC Prescriptive Path/Air Economizers

High Limit Shutoff

(Section 6.3.1.1.3)

- Automatically reduce outside air intake to 6.1.2 of ASHRAE Standard 62 when outside air intake will no longer reduce cooling energy usage
- Control types for specific climates from Table 6.3.1.1.3A
- Settings from Table 6.3.1.1.3B

HVAC Prescriptive Path/Air Economizers

Dampers
(Section 6.3.1.1.4)

- Return air and outside air dampers to have maximum leakage rate of 20 cfm

HVAC Prescriptive Path/Air Economizers

Relief of Excess Outside Air *(Section 6.3.1.1.5)*

- Means to relieve excess outdoor air during economizer operation to prevent overpressurizing the building
- Outlet located to avoid recirculation into the building

HVAC Prescriptive Path/Water Economizers

Design Capacity
(Section 6.3.1.2.1)

- System capable of cooling supply air by indirect evaporation and providing up to 100% of expected system cooling load at outside air temperatures of 50°F dry bulb/45°F wet bulb and below
- Exception
  - If the building dehumidification requirements cannot be met at the above condition, you can also meet this requirement if your design can meet 100% of expected cooling load at 45°F dry bulb/40°F wet bulb

HVAC Prescriptive Path/Water Economizers

Maximum Pressure Drop
(Section 6.3.1.2.2)

- Precooling coils and water-to-water heat exchangers to have either
  - Water-side pressure drop of < 15 ft of water **OR**
  - Create a secondary loop so the coil or heat exchanger pressure drop isn't seen by the circulating pumps when the system is in normal cooling mode

HVAC Prescriptive Path/Water Economizers

Integrated Economizer Control *(Section 6.3.1.3)*

- Economizers must be integrated with mechanical cooling systems and be capable of providing partial cooling even when additional mechanical cooling is required
- Some exceptions to this

HVAC Prescriptive Path/Water Economizers

Economizer Heating System Impact *(Section 6.3.1.4)*

- Designed so economizer operation doesn't increase the building heating energy use during normal operation
- Exception
  - Where heating is allowed by 6.3.2

HVAC Prescriptive Path

Simultaneous Heating and Cooling Limitation

(Section 6.3.2)

- Zone controls capable of operating in sequence the supply of heating and cooling energy to the zone to prevent reheating, recooling, mixing or simultaneously supplying air previously heated or cooled
- Hydronic system controls to prevent reheating or recooling of fluids

HVAC Prescriptive Path

Simultaneous Heating and Cooling Limitation *(cont'd)*

- Dehumidification controls for humidistats to prevent reheating, mixing, etc
- Humidification controls

HVAC Prescriptive Path

Zone Controls

(Section 6.3.2.1)

- Capable of operating in sequence the supply of heating and cooling energy to the zone
- Controls prevent
  - Reheating
  - Recooling
  - Mixing or simultaneously supplying air previously heated or cooled
  - Other simultaneous operation of heating and cooling systems to the same zone

HVAC Prescriptive Path

Zone Controls - Exceptions

- Zones for which volume of air that is reheated, recooled, or mixed is no greater than the larger of the following
  - Volume of outside air to meet 6.1.3 of ASHRAE 62 for the zone
  - 0.4 cfm/ft^2 of zone conditioned floor area with several conditions
  - 300 cfm for zones whose peak flow rate totals no more than 10% of the total fan system flow rate
  - Any higher rate that can be demonstrated to jurisdiction to reduce overall system annual energy usage…
- Zones where special pressurization relationships, cross-contamination requirements, or code-required minimum circulation rates are such that the variable air volume systems are impractical

HVAC Prescriptive Path

Hydronic System Controls

(Section 6.3.2.2)

- Limit heating and cooling of fluids previously heated or cooled mechanically per 6.3.2.2.1 and 6.3.2.2.3

HVAC Prescriptive Path

Three-Pipe System

(Section 6.3.2.2.1)

- No common return system for both hot and chilled water

HVAC Prescriptive Path

Two-Pipe Changeover System *(Section 6.3.2.2.2)*

- Common distribution system acceptable if
  - Deadband from one mode to another is ≥ 15°F outside air temperature
  - Controls to allow operation of ≥ 4 hours before changing over
  - Reset controls so heating and cooling supply temperatures at changeover point no more than 30°F apart

HVAC Prescriptive Path

Hydronic (Water Loop) Heat Pump Systems *(Section 6.3.2.2.3)*

- Controls to provide heat pump water supply temperature deadband of at least 20°F between initiation of heat rejection and heat addition by central devices
- Cooling tower bypass or cooling tower isolation dampers
- A two-position valve at each hydronic heat pump for hydronic systems having a total pump system power > 10 hp
- Exception
  - If system loop temperature optimization controller is used, deadband < 20°F is allowed

HVAC Prescriptive Path

Dehumidification

(Section 6.3.2.3)

- Humidistatic controls to prevent
  - Reheating
  - Mixing of hot and cold air streams
  - Heating and cooling of same air stream

Dehumidification Exceptions

- Systems capable of reducing supply air flow to 50%, or to minimum ventilation
- Systems under 6.67 tons that can unload at least 50%
- Systems smaller than 3.3 tons
- Process applications
- 75% of reheat or recool energy is recovered or solar

HVAC Prescriptive Path

Humidification

(Section 6.3.2.4)

- Systems with hydronic cooling and humidification systems designed to maintain inside humidity at > 35°F dewpoint temperature shall use a water economizer if required by 6.3.1

HVAC Prescriptive Path

Air System Design and Control *(Section 6.3.3)*

- HVAC systems with total fan system power > 5 hp to meet 6.3.3.1 through 6.3.3.3
  - Fan Power Limitation
  - VAV Fan Control
    - Part Load Fan Power Limitation
    - Static Pressure Sensor location
    - Set Point Reset

HVAC Prescriptive Path

Fan Power Limitation
(Section 6.3.3.1)

- Table 6.3.3.1
- Allowable fan system power may be adjusted if
  - Air systems require air treatment or filtering systems with pressure drops > 1 in. w.c. when filters are clean, or heat recovery coils or devices, or direct evaporative humidifiers/coolers, or other devices to serve process loads in the airstream
- If
  - design room temperature – supply air temp at cooling design condition = > 20°F, allowable fan system power may be adjusted

HVAC Prescriptive Path

Part-Load Fan Power Limitation
(Section 6.3.3.2.1)

- Individual VAV fans with motors ≥30 hp
  - Have other controls and devices to result in fan motor demand ≤ 30% of design wattage at 50% of design air volume when static pressure set point = 1/3 of total design static pressure, based on manufacturer's certified fan data

HVAC Prescriptive Path

Static Pressure Sensor Location *(Section 6.3.3.2.2)*

- Placed so controller set point is ≤ 1/3 the total design fan static pressure
  - Except for digital control systems with zone reset capabilities where it may be at the fan discharge
- If this results in the sensor being located downstream of major duct splits, install multiple sensors in each major branch

HVAC Prescriptive Path

Set Point Reset

(Section 6.3.3.2.3)

- For systems with direct digital control of individual zone boxes reporting to the central control panel
  - Static pressure set point reset based on zone requiring the most pressure

HVAC Prescriptive Path

Hydronic System Design and Control *(Section 6.3.4)*

- HVAC hydronic systems with total pump system power > 10 hp shall meet 6.3.4.1 – 6.3.4.3
  - Hydronic Variable Flow Systems
  - Pump Isolation
  - Chilled and Hot Water Temperature Reset

HVAC Prescriptive Path

Hydronic Variable Flow

(Section 6.3.4.1)

- HVAC pumping systems to include control valves
  - Designed to modulate or step open and close as a function of load
  - Designed for variable fluid flow
  - Capable of reducing flow rates to ≤ 50% of design flow rate
- Individual pumps serving variable flow systems with a pump head > 100 ft and motor > 50 hp
  - Have controls and/or devices resulting in pump motor demand
    ≤ 30% of design wattage at 50% of design water flow

HVAC Prescriptive Path

Hydronic Variable Flow - Exceptions

- Systems where
  - Minimum flow is < minimum flow required by equipment manufacturer for proper operation of equipment served by the system
  - Total pump system power ≤ 75 hp
- Systems that include ≤ 3 control valves

HVAC Prescriptive Path

Pump Isolation

(Section 6.3.4.2)

- If chilled water plant has more than one chiller or boiler plant has more than one boiler
  - Provide for flow reduction when chiller or boiler is shut down

HVAC Prescriptive Path

Chilled and Hot Water Temperature Reset Controls *(Section 6.3.4.3)*

- Affects systems with design capacity > 300,000 Btu/h
  - To include controls to automatically reset supply water temperatures by representative building loads (including return water temperature) or by outside air temperature
- Exceptions
  - Would result in improper operation
  - Hydronic systems with variable flow

HVAC Prescriptive Path

Heat Rejection Equipment *(Section 6.3.5)*

- Applies to heat rejection equipment used in comfort cooling systems such as
  - Air-cooled condensers
  - Open cooling towers
  - Closed-circuit cooling towers
  - Evaporative condensers
- Exceptions
  - Heat rejection devices included as an integral part of equipment listed in Tables 6.2.1A-6.2.1D

HVAC Prescriptive Path

Fan Speed Control

(Section 6.3.5.2)

- Each fan powered by a motor ≥ 7.5 hp
  - Have capability to operate fan at ≤ 2/3 full speed
  - Have controls to automatically change the fan speed to control the leaving fluid temperature or condensing temperature/pressure of the heat rejection device
- Exceptions
  - Condenser fans serving multiple refrigerant circuits or flooded condensers
  - Installations located in climates > 7500 CDD50
  - 1/3 of the fans on a multiple fan application speed controlled

HVAC Prescriptive Path

Exhaust Air Energy Recovery *(Section 6.3.6.1)*

- Incorporate exhaust air energy recovery in systems with
  - ≥ 70% outside air and ≥ 5000 cfm total
  - 50% energy recovery effectiveness

HVAC Prescriptive Path

Exhaust Air Energy Recovery Exceptions

- Lab systems meeting 6.3.7.2
- Systems serving uncooled spaces that are heated to < 60°F
- Systems exhausting toxic, flammable, paint or corrosive fumes or dust
- Commercial kitchen hoods classified as Type 1 by NFPA 96
- Where > 60% of outdoor heating energy is provided from site-recovered or site solar energy
- Heating systems in climates < 3600 HDD65
- Cooling systems in climates with a 2.5% cooling design wet-bulb temperature < 65°F
- Where largest exhaust source is < 75% of the design outdoor airflow
- Systems requiring dehumidification that employ series-style energy recovery coils wrapped around the cooling coil

HVAC Prescriptive Path

Heat Recovery for Service Water Heating *(Section 6.3.6.2)*

- Condenser recovery required if
  - 24 hrs per day and
  - Heat rejection > 6,000,000 Btu/h and
  - SWH load > 1,000,000 Btu/h

HVAC Prescriptive Path

Kitchen Hoods (Exhaust)

(Section 6.3.7.1)

- Hoods > 5000 cfm to be provided with makeup air sized for at least 50% of exhaust air volume that is a) unheated or heated to more than 60°F and b) uncooled or cooled without the use of mechanical cooling
- Exceptions
  - Where hoods are used to exhaust ventilation air that would otherwise exfiltrate or be exhausted by other fan systems
  - Certified grease extractor hoods that require a face velocity no greater than 60 fpm

HVAC Prescriptive Path

Fume Hoods (Exhaust)

(Section 6.3.7.2)

- Hood systems with a total exhaust rate > 15,000 cfm to have ONE of the following features
  - Operation to < 50% design flow OR
  - Direct make up at least 75% of exhaust rate at specified conditions OR
  - Heat recovery for make-up air

HVAC Prescriptive Path

Radiant Heating Systems

(Section 6.3.8)

- Required for unenclosed spaces except loading docks with air curtains
- “Radiant heating systems that are used as primary or supplemental enclosed space heating must be in conformance with the governing provisions of the standard”

HVAC Prescriptive Path

Hot Gas Bypass Limitation
(Section 6.3.9)

- Not used (including other evaporator pressure control systems) unless system is designed with multiple steps of unloading or continuous capacity modulation
- Exception
  - Unitary packaged systems with cooling capacities ≤ 90,000 Btu/h

Service Water Heating
Chapter 8 Scope

Chapter 8

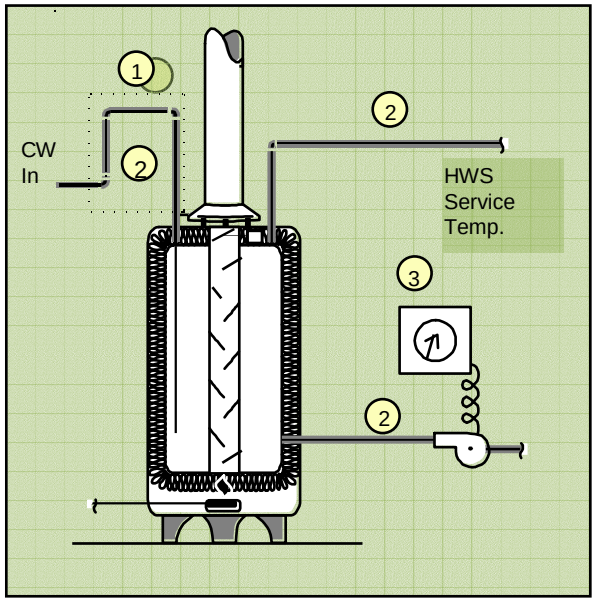
Section 804

Chapter 7

Section 7

Water Heating

- Summary of requirements



1. Heat traps to reduce standby losses
2. Pipe insulation to reduce distribution and standby losses
3. Circulation loop temperature controls to reduce distribution losses

Equipment Efficiency
(Section 804.2)

Service Water Heating

- **Equipment efficiency**
- Temperature controls
- Heat traps
- Pipe insulation
- Hot water system controls

- NAECA regulated water heating equipment allowed under the IECC
  - Electric heaters
  - Fuel-fired storage
  - Packaged boilers
  - Instantaneous
  - Pool and spa heaters
- Non NAECA regulated water heating equipment
  - Gas/oil

Temperature Controls
(Section 804.3)

Service Water Heating

- Equipment efficiency
- **Temperature controls**
- Heat traps
- Pipe insulation
- Hot water system controls

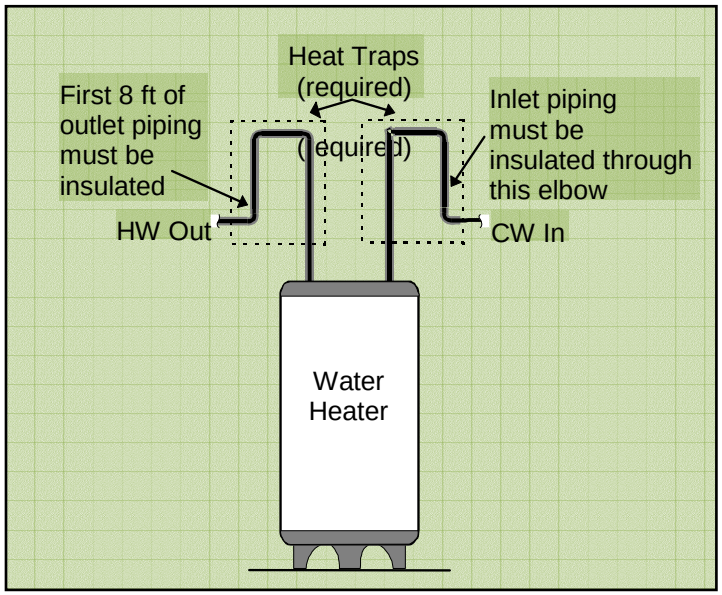
- Setpoints
  - 110°F for dwelling units
  - 90°F for other occupancies
- Outlet temperature of lavatories in public facility rest rooms limited to 110°F

Heat Traps
(Section 804.4)

Service Water Heating

- Equipment efficiency
- Temperature controls
- **Heat traps**
- Pipe insulation
- Hot water system controls

- Required on noncirculating hot water systems



Pipe Insulation
(Section 804.5)

Service Water Heating

- Equipment efficiency
- Temperature controls
- Heat traps
- **Pipe insulation**
- Hot water system controls

- Noncirculating system insulation requirements
  - First eight feet of outlet piping on systems with no integral heat traps
  - 1/2 inch of insulation required
- Circulating systems
  - 1 inch of insulation

Hot Water System Controls
(Section 804.6)

Service Water Heating

- Equipment efficiency
- Temperature controls
- Heat traps
- Pipe insulation
- **Hot water system controls**

- Application: circulating hot water systems
  - Automatic time switches required to turn off the pump and heat tracer tape when it is not in use

Service Water Heating
Chapter 7 Scope

Chapter 8

Section 804

Chapter 7

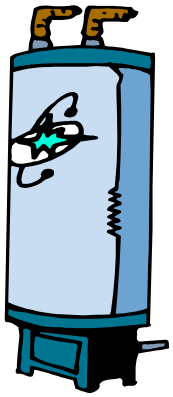
Section 7

Swimming Pools

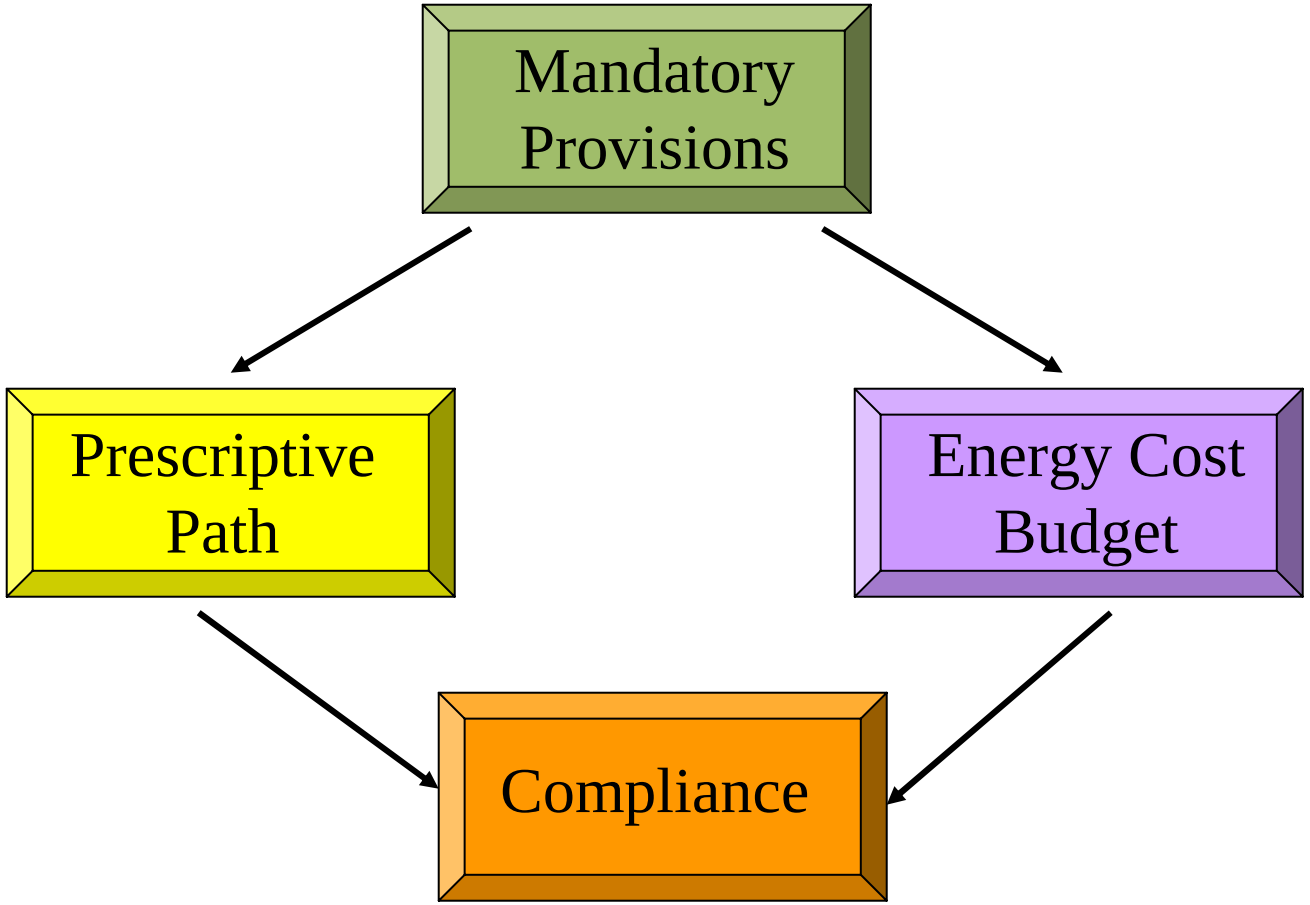
Combined Service Water Heating & Space Heating

Section 7 - Service Water Heating

- General *(Section 7.1)*
- Mandatory Provisions *(Section 7.2)*
  - Sizing of systems
  - Equipment efficiency
  - Service hot water piping insulation
  - System controls
  - Pools
  - Heat traps
  - Space heating and water heating
  - Service water heating equipment
- Prescriptive Path *(Section 7.3)*



SWH Compliance
(Section 7.1.2)

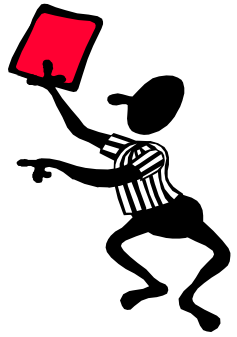


Mandatory Provisions

SWH Mandatory Provisions

Sizing of Systems

(Section 7.2.1)



- In accordance with manufacturer's published sizing guidelines

SWH Mandatory Provisions

Equipment Efficiency

(Section 7.2.2)

- Table 7.2.2
- Equipment not listed in Table 7.2.2 has no minimum performance requirements
- Exception
  - Water heaters and hot water supply boilers > 140 gal storage capacity don't have to meet standby loss requirements when
    - Tank surface is thermally insulated to R-12.5, and
    - A standing pilot light isn't installed, and
    - Gas- or oil-fired water heaters have a flue damper or fan-assisted combustion

SWH Mandatory Provisions

Service Hot Water Piping Insulation *(Section 7.2.3)*

- Table 6.2.4.5, Section 6
- Circulating water heater
  - Recirculating system piping, including supply and return piping
- Nonrecirculating storage system
  - First 8 ft of outlet piping
  - Inlet pipe between storage tank and heat trap
- Externally-heated pipes (heat trace or impedance heating)

SWH Mandatory Provisions

System Controls

(Section 7.2.4)

- Temperature Controls
- Temperature Maintenance Controls
- Outlet Temperature Controls
- Circulating Pump Controls

SWH Mandatory Provisions

Temperature Controls
(Section 7.2.4.1)

- To allow for storage temperature adjustment from 120°F or lower to a maximum temperature compatible with the intended use
- Exception
  - If manufacturer's installation instructions specify a higher minimum thermostat setting to minimize condensation and resulting corrosion

SWH Mandatory Provisions

Temperature Maintenance Controls *(Section 7.2.4.2)*

- Automatic time switches or other controls
  - Set to switch off usage temperature maintenance system during extended periods when hot water is not required

SWH Mandatory Provisions

Outlet Temperature Controls *(Section 7.2.4.3)*

- Automatic time switches or other controls
  - To limit maximum temperature of water delivered from lavatory faucets in public facility restrooms to 110°F

SWH Mandatory Provisions

Circulating Pump Controls

(Section 7.2.4.4)

- To limit operation to a period from the start of the heating cycle to a maximum of five minutes after the end of the heating cycle

SWH Mandatory Provisions

Pools

(Section 7.2.5)

- Pool heaters to have readily accessible on-off switch
- Pool heaters fired by natural gas to NOT have continuously burning pilot lights
- Vapor retardant pool covers required (unless recovered or solar heat)
- Time switches required

SWH Mandatory Provisions

Heat Traps

(Section 7.2.6)

- Noncirculating systems to have heat traps on both the inlet and outlet piping as close as practical to storage tank (if no integral heat traps)
  - Either a device specifically designed for this purpose or
  - Arrangement of tubing that forms a loop of 360° or piping that form the point of connection to the water heater includes a length of piping directed downward before connection to the vertical piping of the supply water or hot water distribution system, as applicable

Prescriptive Path

SWH Prescriptive Path

Space Heating and Water Heating *(Section 7.3.1)*

- Gas- or oil-fired space heating boiler system (complying with Section 6) is allowed to provide total space heating and water heating when ONE of the following conditions is met
  - Single boiler or component that is heating the service water has a standby loss in Btu/h not exceeding
    - (13.3 x *pmd* + 400) / *n*; where *pmd* is probable maximum demand in gal/h and *n* is the fraction of the year when outdoor daily mean temperature is > 64.9°F
  - Jurisdiction agrees use of a single heat source will consume less energy than separate units
  - Energy input of the combined boiler and water heater system is < 150,000 Btu/h
- Instructions for determining standby loss are included in this Section

SWH/Prescriptive Path

Service Water Heating Equipment *(Section 7.3.2)*

- Equipment used to provide the additional function of space heating as part of a combination (integrated) system shall satisfy all requirements for service water heating equipment

Lighting Systems
Chapter 8 Scope

Chapter 8

Section 805

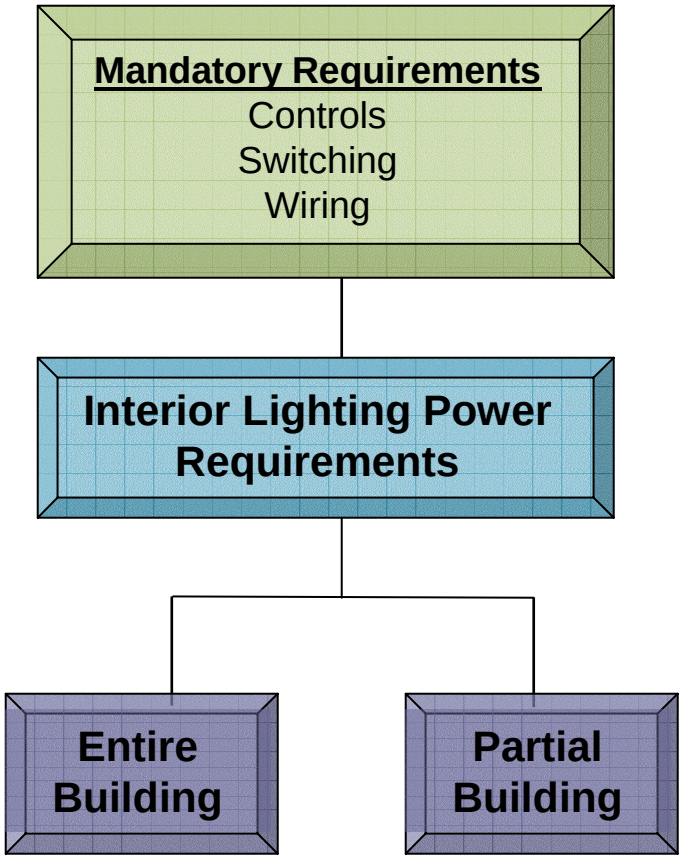
Chapter 7

Section 9

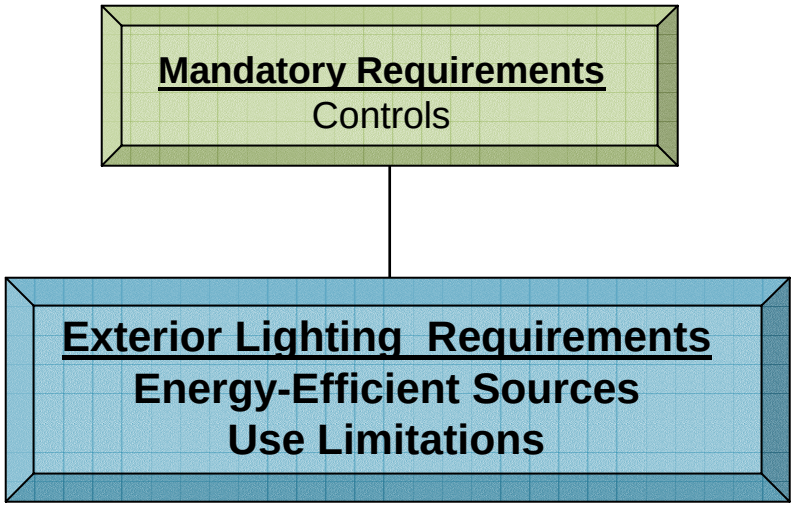
Scope

- Applies to the design of the:
  - first installed lighting systems
  - altered system that increases the lighting load if change of occupancy
- Lighting systems used for specialized commercial, display and emergency use purposes are exempt *(Section 805.4.1)*

Scope – Interior Lighting Requirements



Scope – Exterior Lighting Requirements

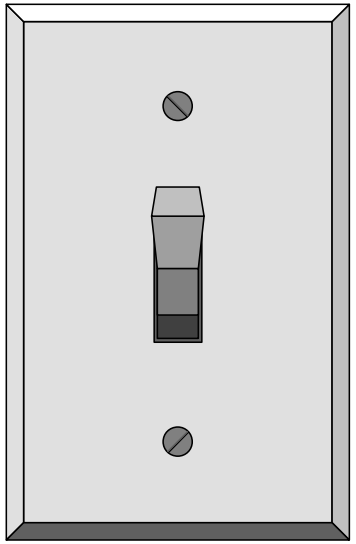


Mandatory Requirements

Independent Switching

(Section 805.2.1)

- Lighting controls required for each area enclosed by ceiling height partitions
- Switch locations
  - In view of lights
  - "On" or "off" indication from remote location
  - Occupancy sensor



Independent Switching

- Exceptions
  - Emergency/security lighting
  - Stairway or corridor lighting for egress

Mandatory Requirements

Additional Controls

(Section 805.2.2)

- Each area required to have a mandatory control to have additional controls to meet requirements of…..
- Exceptions
  - Areas with only 1 luminaire
  - Areas with an occupant-sensing device
  - Corridors, storerooms, restrooms, or public lobbies

Mandatory Requirements

Bi-Level Switching
(Section 805.2.2.1)

- Areas < 250 ft^2 that are required to have manual control shall also
  - Reduce connected lighting load uniformly by 50% for each space
  - Exceptions
    - Area has one luminaire
    - Occupancy sensor controls area
    - Area is corridor, storeroom, restroom, or public lobby

Mandatory Requirements

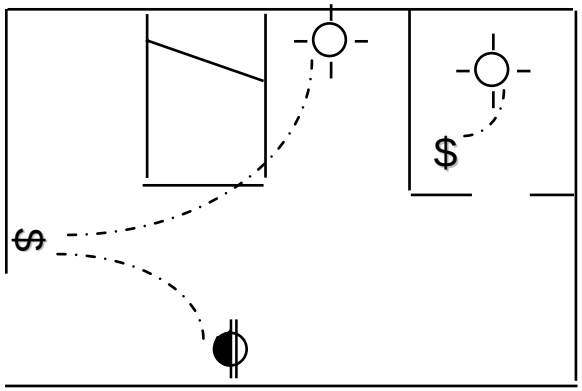
Automatic Lighting Shutoff
(Section 805.2.2.2)

- In buildings > 5000 ft^2
  - Spaces > 250 ft^2 must have automatic control devices to function either on
    - Scheduled basis using time-of-day
    - Unscheduled basis by occupant intervention

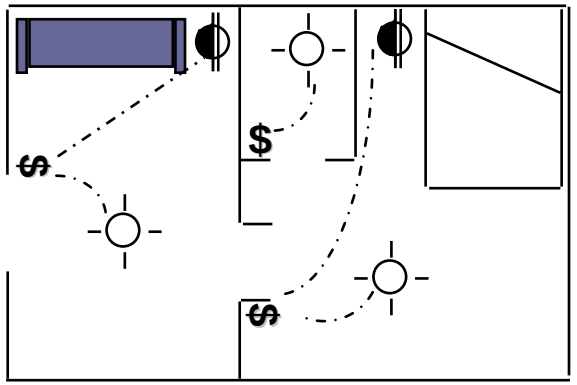
Mandatory Requirements

Hotel/Motel Guest Room Switching (*Section 805.2.2.3*)

- Master switch required at entry



Standard Room



Suite

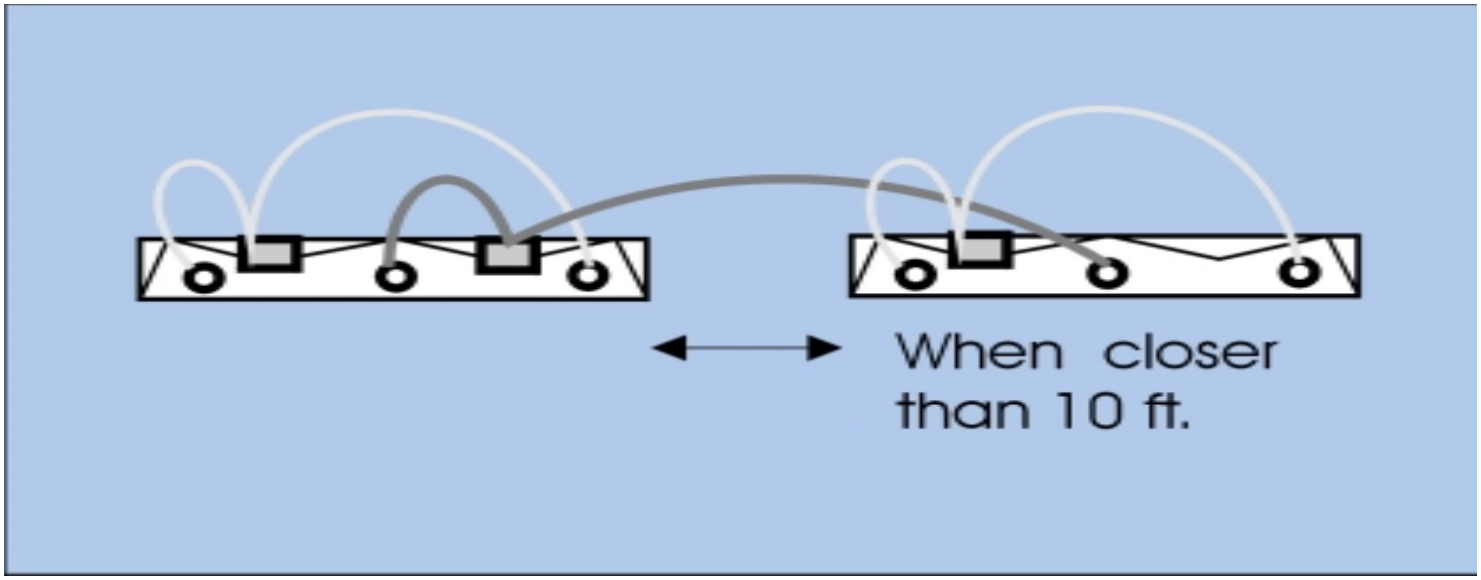
Mandatory Requirements

Exterior Lighting Controls

(Section 805.2.3)

- Must be capable of automatically turning lights off when daylight is available
- Eligible controls
  - Directional photocell
  - Astronomical time switch
  - Building automation system with astronomical time switch capabilities
- Exceptions
  - Covered areas requiring illumination during daylight hours

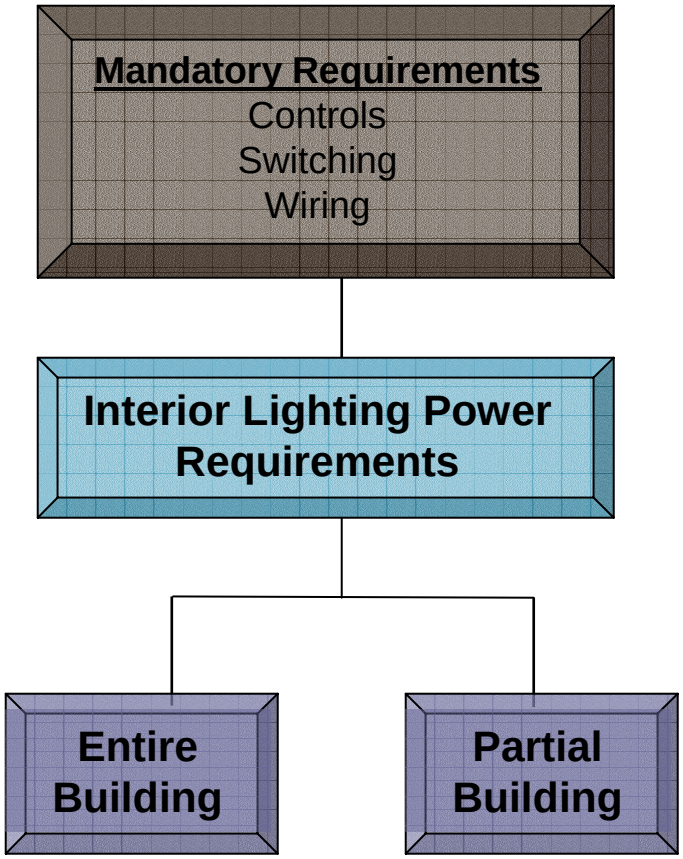
Tandem Wiring
(Section 805.3)



Tandem Wiring

- Exceptions
  - Luminaires with electronic high-frequency ballasts
  - Luminaires not on same switch controls or not in the same area

Interior Lighting Requirements



Total Connected Power
(Section 805.4.1)

- Total connected lighting wattage includes:
  - Lamp wattage
  - Ballast wattage
- Sources of bulb/ballast wattages
  - Manufacturer's literature
  - Industry default tables

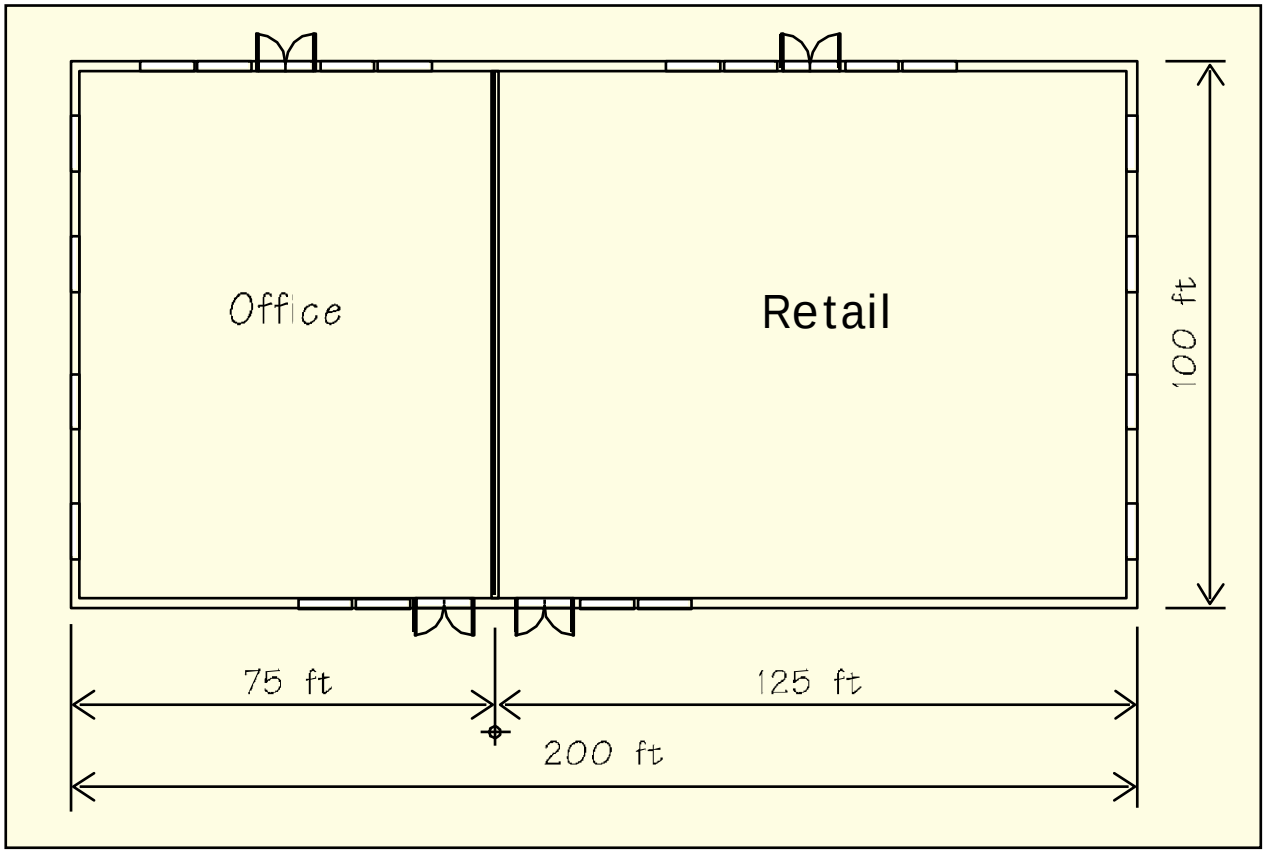
Total Connected Power

- Exceptions
  - Specialized medical, dental, and research lighting
  - Professional sports arena playing field lighting
  - Display lighting for gallery exhibits, museums, and monuments
  - Guest room lighting in hotels, motels, boarding houses, or similar buildings
  - Emergency lighting automatically off during normal building operation

Interior Lighting Power
(Section 805.4.2)

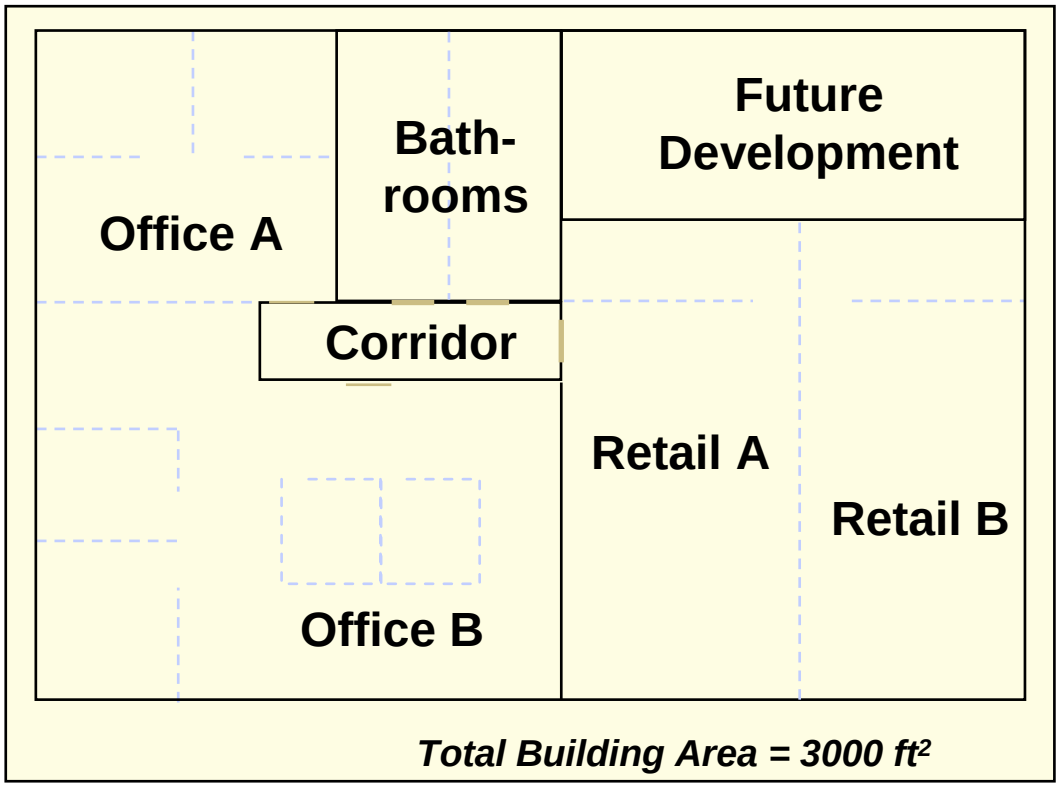
- Entire building
  - Building is all one occupancy or a majority occupancy exists *(Section 101.4.3)*
- Tenant area or portion of building
  - Use for tenant spaces in larger building or divide whole building into area types
- Table 805.4.2

What is the Interior Lighting Power Budget for this Building?



What is the Interior Lighting Power Budget for this Building?

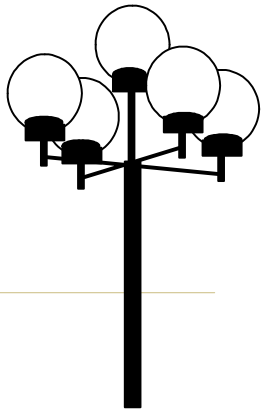
Office A:	**400 ft^2**
Office B:	**850 ft^2**
Bathrooms:	**350 ft^2**
Corridor:	**50 ft^2**
Retail A:	**500 ft^2**
Retail B:	**500 ft^2**
Future:	**350 ft^2**



Does the Building Comply?

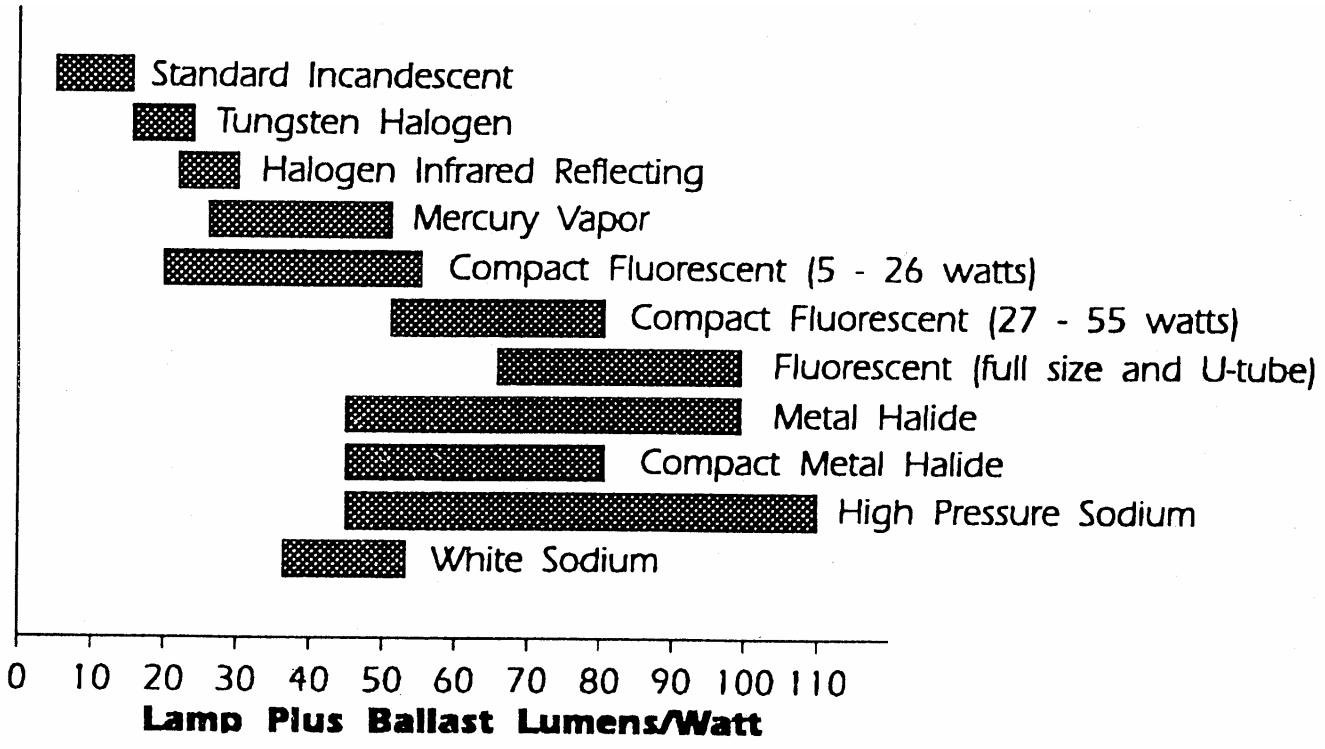
- Determine the total connected power in watts for the proposed lighting
- Determine the interior lighting power budget for the entire building or space
- Building complies if:
  - Interior lighting power budget - total connected power ≥ 0

Exterior Lighting
(Section 805.5)



- Criteria
  - Lighting power supplied through building electrical service
  - Must use energy-efficient lighting sources to highlight paths, walkways and parking areas
    - ≥ 45 Lumens/Watt
    - Fluorescent
    - Compact Fluorescent
    - Metal Halide
    - High Pressure Sodium

Energy-Efficient Lighting Sources



Exterior Lighting

- Exceptions
  - Where approved because of the following considerations:
    - Historical
    - Safety
    - Signage
    - Emergency

Electrical/Lighting
Chapter 7 Scope

Chapter 8

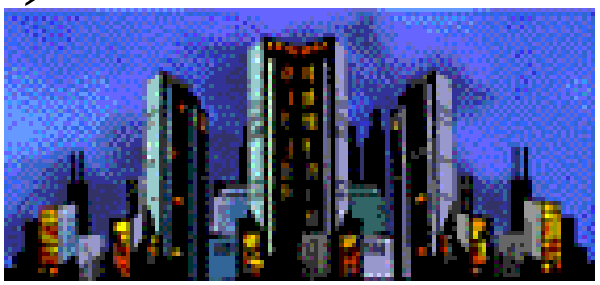
Section 805

Chapter 7

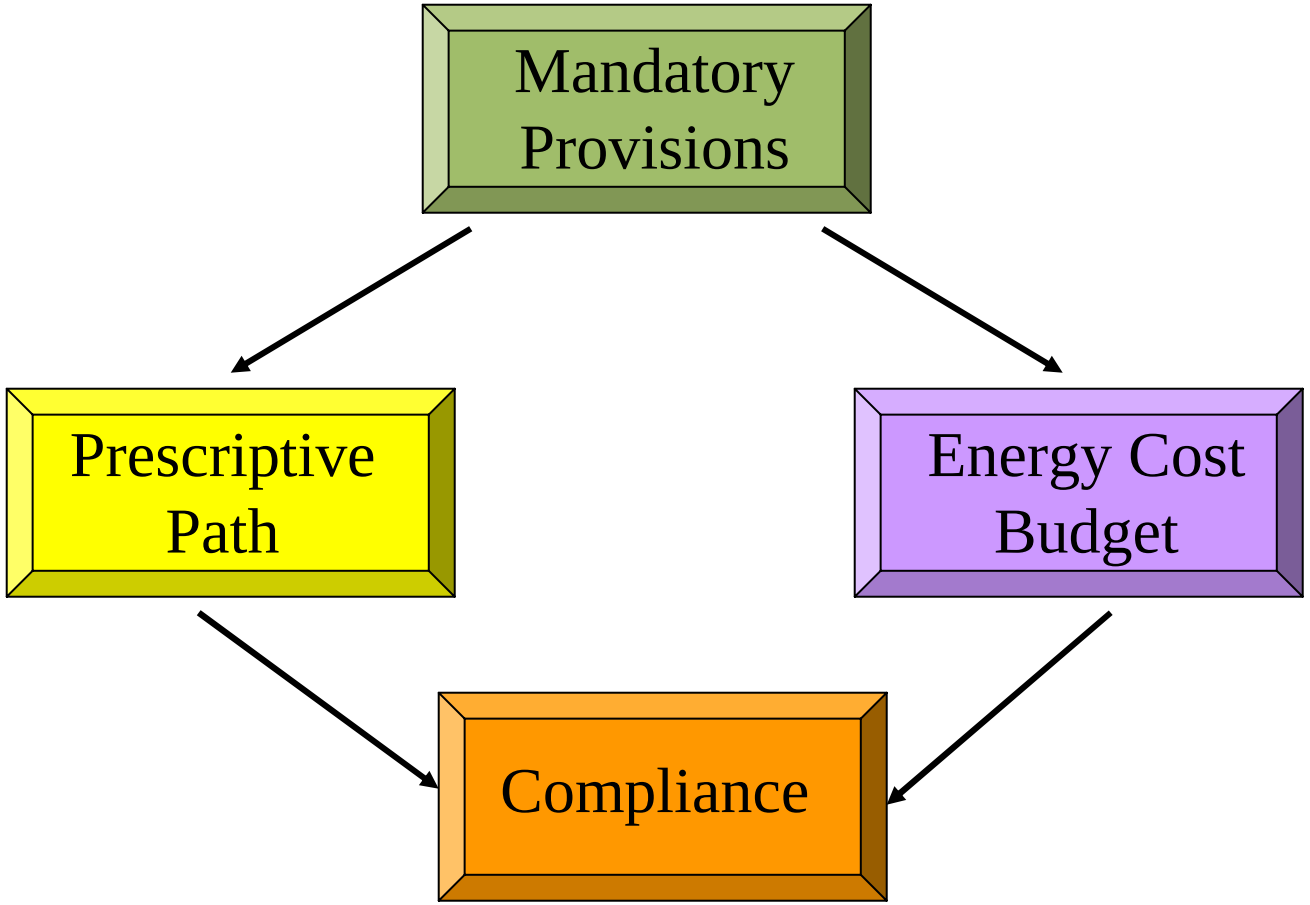
Section 9

Section 9 - Lighting

- General Application *(Section 9.1)*
- Mandatory Provisions *(Section 9.2)*
  - Lighting controls
  - Tandem wiring
  - Exit signs
  - Installed interior lighting power
  - Luminaire wattage
  - Exterior building grounds lighting
- Prescriptive Path *(Section 9.3)*
  - Interior Lighting Power Allowance
    - Building Area Method
    - Space-by-Space Method
  - Exterior Lighting Power Allowance



Lighting Compliance



Lighting General Application

- Interior spaces of buildings
- Exterior building features
- Exterior grounds lighting powered through building
- Exceptions
  - Emergency lighting
  - Lighting required by life safety statute
  - Lighting within living units of buildings
  - Decorative gas lighting

Lighting Changes Between 90.1-1989 and 90.1-1999

- More efficient lighting
  - Less power allowed
- No lighting control credits
  - Lighting power allowance now based only on connected lighting power
- No control points for spaces
- No separate lighting controls for daylighted spaces

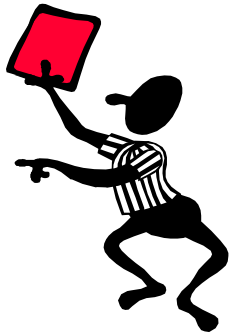
Lighting Changes Between 90.1-1989 and 90.1-1999 *(cont'd)*

- Automatic shutoff controls required
- Most exterior power requirements replaced with minimum efficacy requirements
  - Parking garages included in interior lighting
- Interior power requirements updated
  - More stringent requirements
  - Area factors no longer need to be calculated
  - Building area allowances no longer depend on size
- Additional power allowances for certain specialty lighting

Lighting Scope

- New construction
- Existing nonresidential and high-rise residential
  - If ≥ 50% of existing luminaires are replaced
  - If renovation increases lighting power
- Control devices can't control
  - > 2500 ft^2 in spaces < 10,000 ft^2
  - > 10,000 ft^2 in spaces > 10,000 ft^2
- Control must be readily accessible and located so occupants can see the controlled lighting

Mandatory Provisions



Lighting Mandatory Provisions
Lighting Control
(Section 9.2.1)

- Automatic lighting shutoff
  - Applies to buildings > 5000 ft^2
    - Time-scheduling devices
      - Accommodate separate schedules for each floor or each space > 25,000 ft^2
    - Occupant-sensing devices
      - All general lighting controlled by one or more occupant sensors
      - Must turn off lights in each controlled space within 30 minutes of last occupant detection

Lighting Mandatory Provisions

Space Control

(Section 9.2.1.2)

- At least one for each room or space enclosed by ceiling-height partitions
- Readily accessible to occupants
  - Except for safety or security
- In spaces $\leq$ 10,000 ft^2, each control can serve a maximum of 2500 ft^2
- In spaces > 10,000 ft^2, each control can serve a maximum of 10,000 ft^2

Lighting Mandatory Provisions

Exterior Lighting Control
(Section 9.2.1.3)

- Photocells or astronomical time switch required
- Seven-day electrically-driven, mechanical clocks with trippers, astronomical dial, and four-hour spring-wound storage
- Seven-day or calendar year, electronic programmable time switches with astronomic correction and battery backup
- Any of the timers above with a photocell (in place of astronomical correction)
- Exceptions – lighting for
  - Covered vehicle entrances
  - Exits from buildings or parking structures

  (where required for safety, security, or eye adaptation)

Lighting Mandatory Provisions

Additional Control

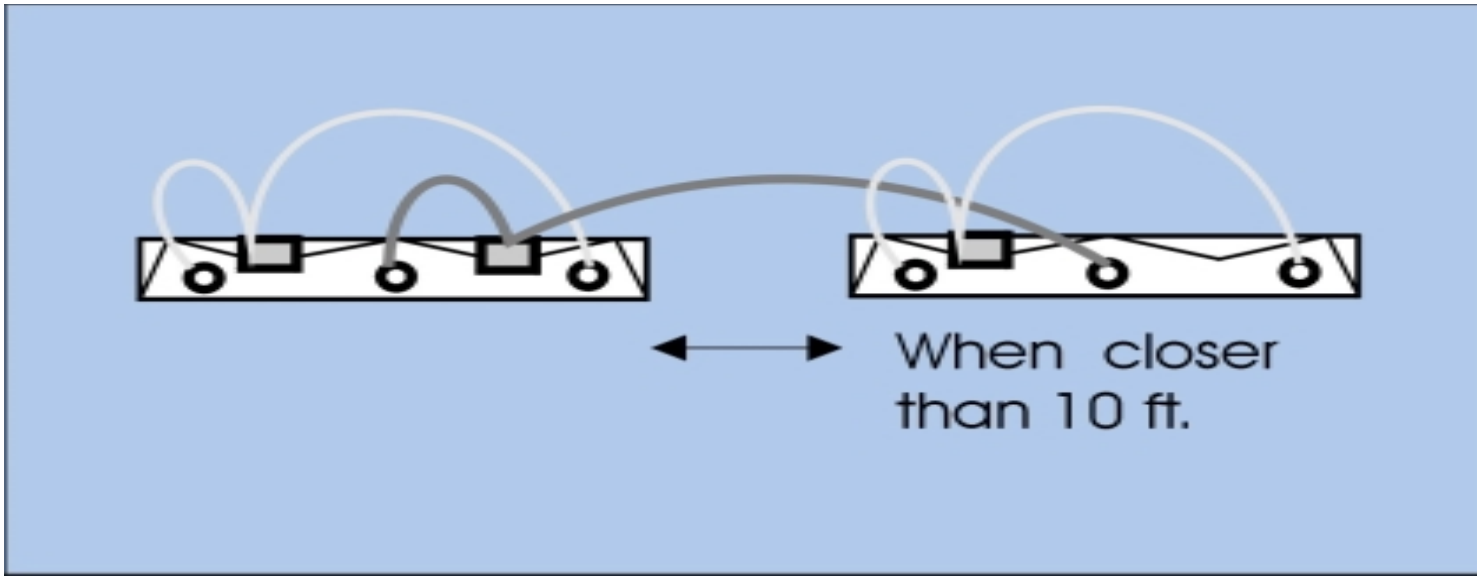
(Section 9.2.1.4)

- Many special lighting applications must be controlled separately
  - Display/accent lighting
  - Case lighting
  - Hotel/motel guest room lighting
  - Task lighting
  - Nonvisual lighting
  - Demonstration lighting

Lighting Mandatory Provisions

Tandem Wiring

(Section 9.2.2)



Lighting Mandatory Provisions

Tandem Wiring Exceptions
(Section 9.2.2)

- Separated surface or pendant luminaires
- Recessed luminaires more than 10 ft apart
- Other luminaires
  - With three-lamp ballasts
  - On emergency lighting circuits
  - With no available pair
  - With one lamp, high frequency, electronic ballast

Lighting Mandatory Provisions

Exit Signs

(Section 9.2.3)

- Exit signs operating at > 20 W must have a source efficacy ≥ 35 lumens/W
- LED lamps okay
- CF lamps with electronic ballasts usually okay
- Majority of incandescent lamps not okay

Efficacy

- The ratio of light output to watts input
  - lumens per watt
- The higher the efficacy, the more efficient the light source
  - 40 watt incandescent = 480 lumens
  - 40 watt fluorescent = 2640 lumens

Lighting Mandatory Provisions

Installed Interior Lighting Power *(Section 9.2.4)*

- Includes all permanent and portable interior lighting intended for general, ambient, or task illumination
- Includes lamp, power used by ballast, the control (when applicable), current regulators, and any other power draws associated with the lighting system
- Exception
  - If 2 or more independently operating lighting systems in a space can be controlled to prevent simultaneous operation, can base IILP on lighting system with highest wattage

Lighting Mandatory Provisions

Luminaire Wattage

(Section 9.2.5)

- Standard incandescent = max. labeled wattage of the luminaire
- Luminaires with ballasts = wattage of the lamp/ballast combination
- Line voltage track = min. 30 W per foot
- Low voltage track = transformer wattage
- All others as specified

Lighting Power Development Concept

- Create building space models to calculate power densities with:
  - Current product performance data
  - Updated efficacy and loss factors
  - New building construction data
  - IES-recommended light levels
  - Professional lighting design consensus

Lighting Mandatory Provisions

Exterior Building Grounds Lighting *(Section 9.2.6)*

- Luminaires that operate at > 100 W = efficacy > 60 lumens/W
- Exceptions
  - Traffic signals
  - Lighting within outdoor signs
  - Lighting used to illuminate public monuments or registered historic landmarks
  - If an occupancy sensor or motion sensor controls the lighting application

Prescriptive Path

Lighting Prescriptive Path

Interior Lighting Power

- Lots of exemptions
- Calculation methods
  - Building area
  - Space-by-space
  - Trade-offs of interior lighting power allowance among portions of the building for which a different calculation method has been used is not permitted

Lighting Power Allowance Exemptions

- Theatrical, stage, film, and video production
- Medical and dental procedures
- Exhibit displays for museums monuments, and galleries
- Plant growth or maintenance
- Integral to equipment or instrumentation installed by manufacturer
- Integral to both open and glass-enclosed refrigerator and freezer cases
- Retail display windows, provided the display is enclosed by ceiling-height partitions
- Interior spaces specifically designated as registered interior historic landmarks
- Integral part of advertising or directional signage
- Exit signs
- Sale or lighting educational demonstration systems
- Athletic playing areas with permanent facilities for TV broadcasting
- Casino gaming areas
- For use in areas specifically designed for the visually impaired

Lighting Prescriptive Path

Building Area Method

(Section 9.3.1.1)

- Used for projects involving
  - An entire building
  - A single, independent, and separate occupancy in a multi-occupancy building
- Gross lighted area is multiplied by allowance from Table 9.3.1.1
- Limitations
  - Insensitive to specific space functions and room configurations
  - Generally is more restrictive
  - Does not apply to all building types - but “selection of a reasonably equivalent type” is permitted

Lighting Prescriptive Path

Gross Lighted Area

- Sum of total lighted area of a building
  - Measured from the exterior faces of the exterior walls or from the centerline of walls separating buildings
- Used in the building area method of determining interior lighting power allowance

Lighting Prescriptive Path

Building Area Allowances

- Table 9.3.1.1

Lighting Prescriptive Path

Space-by-Space Method
(Section 9.3.1.2)

- Identify different building types in your project
- Divide gross lighted area of the building into each of the space types
- Calculate lighting power allowance by multiplying area of space type by lighting power density for that specific space type
- Sum all the allowances
- Advantages
  - More flexible
  - Applicable to all building types
  - Accounts for room geometry (e.g., lighting needs of enclosed office vs. open office)

Lighting Prescriptive Path

Additional Interior Lighting Power

- An increase in the ILPA is allowed for specific space functions when using the space-by-space method
  - Decorative – 1.0 W/ft^2 in space used
  - Fluorescent designed to eliminate glare - .35 W/ft^2
  - Lighting equipment installed in retail spaces specifically to highlight merchandise in specific space used
    - Additional 1.6 W/ft^2,or
    - Additional 3.9 W/ft^2 for fine merchandise

Lighting Prescriptive Path

Exterior Building Lighting Power *(Section 9.3.2)*

- Sum of all lighting power allowances for applicable exterior applications
- Building Surface Requirements
  - Building entrance with canopy – 3 W/ft^2
  - Building entrance – 33 W/linear ft
  - Building exit – 20 W/linear ft
  - Building facades – 0.25 W/ft^2
- Exceptions, when equipped with a control device
  - Specialized signal, directional, and market lighting associated with transportation
  - Public monuments
  - Registered historic landmark structures or buildings
  - Lighting integral to advertising signage

Where to Get More Information

- Other training sessions
- COM*check*-*EZ*™
- List books, articles, electronic sources
  - www.energycodes.org
  - www.boca.org
  - www.icbo.org
  - www.sbcci.org
  - Hotline: 1-800-270-CODE